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Contents

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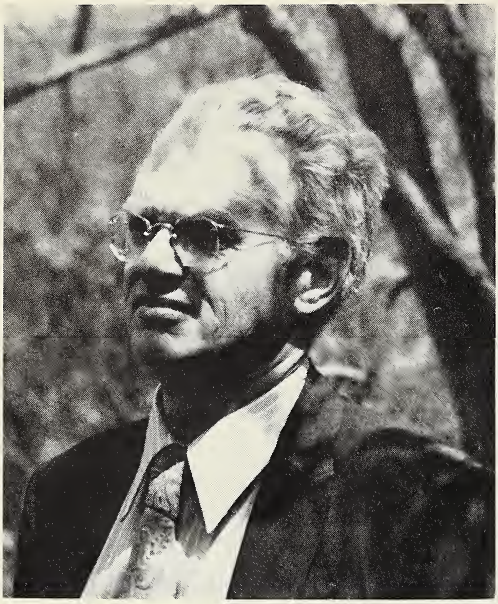
Cover: Tangential section of hemlock wood which is infected with dwarfmistletoe. Photo: L. Srivastava.

Centennial Symposium:

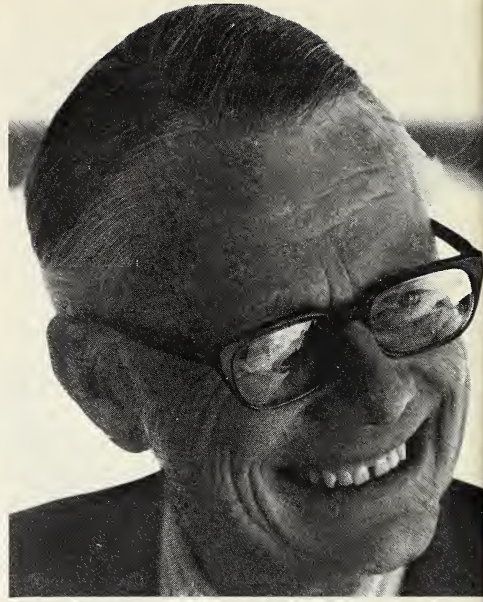
The Potential of Arboreta and Botanical Gardens

[Papers presented during the two concurrent morning sessions of the all day Centennial symposium, May 23, are being reprinted in this issue. In March-April, those of the afternoon sessions will be published, along with the text of the alternate speaker.]

Moderators



HOWARD S. IRWIN, Executive Director of the New York Botanical Garden



R. HENRY NORWEB, JR., Director of the Holden Arboretum

PETER H. RAVEN, Director of the Missouri Botanical Garden and Professor of Biology, Washington University

REED C. ROLLINS, Director of the Gray Herbarium and Asa Gray Professor of Systematic Botany, Harvard University

The Herbarium As a Data-Bank

The practice of collecting plant samples to be preserved for one purpose or another is very old indeed. While initially it may have reflected in part man's inherent curiosity about the natural world around him, he must have collected these samples largely because of some real or fancied property important to his survival. Food plants, medicinal herbs, as well as those with magical powers to control the reactions of friends and/or enemies, are examples of the utilitarian thinking that undergirded the earliest plant collections. These along with pretty stones, fossil bones, butterflies, and other objects of nature were gathered in "cabinets of curiosities". Ultimately, of course, these proto-herbaria were recognized as important documentation of the kinds of plants, their distribution geographically and temporally, and their variability and evolutionary history, but in saying this I have omitted a long period of development of plant collections which continues even now.

In spite of the early interest of Greek philosophers in the properties and identities of plants, the first herbaria, as such, were established only about 425 years ago, in 1543 at Pisa by Luca Ghini (Stearn 1971) and at the University of Padua and Florence in 1545. It was almost 200 years more before herbaria were used extensively in the generation of classificatory systems by Linnaeus and others. Now, 200 years after Linnaeus, something like a thousand herbaria of various sizes, distributed over the world, contain upwards of 200 million specimens. We must recognize this as a significant accomplishment, but also as the source of enormous problems of organization, inter-communication, and support in terms of both people and funds. It is appropriate to the times, especially on this centennial of one of America's great botanical centers, to ask whether the herbarium as an entity continues to meet the needs of modern biology. I believe the most objective answer must be, only partially. If that is true, how can it become more responsive to the present, as well as the anticipated future requirements for botanical information?

We are told (Shetler 1969) that herbaria originated and were

organized by and for the use principally of descriptive botanists. This surely is not surprising nor pejorative. There are many other demands, however, which have existed, or are now emerging in most insistent terms, that must be satisfied somehow if the herbarium is to continue to be a viable organizational entity, supported by society because its information content/accessibility is significant to problem-solving. After all, its principal reason for being is that it is the source of diverse botanical data and as long as only taxonomic purposes are served, there is little cause to restructure anything to recover those data in a timely fashion. However, can the urgent needs of systematic and environmental biology be satisfied by modern herbaria without some modifications in structure, attitudes, functional relationships?

I very much doubt that any man-created institution can survive indefinitely without some genuine, major relationship to the context in which it exists and this is so very true of scientific institutions. As an especially poignant example of the truth of this statement, let me mention briefly the forthcoming national symposium on the development and management of the primary systematic resources; that is, collections and libraries.

One response by the National Science Foundation to the report submitted January 1971 by the Conference of Directors of Systematic Collections is recognition that the needs of systematics resource centers are clearly established. A second response, following closely on the heels of the first, is that the needs surpass present and near-future capabilities of the National Science Foundation to meet them and a "national plan" is essential to distribute what resources may become available in ways that will have the greatest benefit for science and the nation. The evolution of a national plan instantaneously is unlikely but the message is unmistakably clear — the systematics centers must find ways in which they can operate more effectively, *together.* That some of our present autonomy is bound to be sacrificed is obvious but some other, perhaps more drastic, changes will doubtless emerge from such planning in the near future too. The alternative is to maintain the *status quo* and perhaps increasingly lose relevance and, as a consequence, also lose support that is already woefully deficient in most collections centers. So a review at this point of the role of the herbaria as it is and has been, as well as its potential, is a worthwhile objective.

Initially, as I indicated earlier, the creation and maintenance

of plant collections was largely motivated by economics and folk uses but one can believe that the first true herbarium developed at a university because of the necessity to transmit existing botanical knowledge to successive generations through the educational system. This is no less urgent today and most of our universities maintain at least teaching collections, although of the five largest herbaria, with the notable exception of Harvard University, all are at non-degree-granting institutions. In fact, in the last decade there was a considerable trend to transfer all except teaching collections to these great centers but this may have slowed with greater realization of the potential value of these materials and with the passing of the molecular biology bandwagon which has found its proper niche in relation to the rest of biology. What we have seen, I think, is the evolution of two kinds of herbaria, teaching collections and research collections, which may be a healthy division of labors. Most academic centers should perhaps concentrate on the development of teaching collections and documentation of their state and local floras. The research herbaria could be expected to develop global representation of plants from all regions, each herbarium with one or more emphases in which it would be responsible for developing great depth in its collections.

The second major role of herbaria has been to provide services, largely identifications, and such division of responsibilities as suggested above would certainly facilitate this function. Because the roles of many herbaria are inexact and also because there are all too few curators to provide these services, an archaeologist, agriculturist, or ecologist may be totally frustrated in the search for systematic botany data. The largest obstacle to providing such data in a timely way is the lack of people, a shortage which has become more serious in direct proportion to the increase in professionalism of the curator. In earlier times he was frequently little more than a highly competent, knowledgeable cataloger-identifier, often with little understanding of or interest in the broader biological, philosophical bases for his work. With each succeeding generation, the level of professional competence has increased and today's curator must be reckoned with as a serious scientist whose researches are as harmful to interrupt for mundane routine services as are those of the more fashionable sub-disciplines of any moment.

One way in which this impasse that arises from needs for services as well as for research can be met is by the recognition in the major centers of the usefulness of three kinds of individuals — the "curator", the researcher, and the professional

technician. The "curator" is similar to the herbarium botanist of yesteryear, who functioned essentially as a source of identifications and of related data. Motivated by a compulsive desire for order, for knowing *what* grows *where*, he was a most useful scientific colleague. As our understanding of processes and principles expanded in the course of advanced education, a new insistent kind of question was added to those of *what* and *where* — *WHY*. Both sets of questions still are, and always will be, valid but the *WHY-kind* of problems attracted a somewhat different breed to systematic biology, with the care of collections, in some instances, taking second priority. Thus, most major collections might meet needs more adequately with a staff consisting of some para-professional "curators" with technicians, aids, or other assistants to organize the data, the documentation, and to provide services generally. The research staff of such centers are then free to develop, singly and collectively, in concert with practitioners of other disciplines at times, the answers to the many "*whys*" and generally to generate the factual data for providing the services required.

As Shetler (1969) points out, the herbarium has served many purposes, especially those which are based on the concept that the collections are an inventory of plant diversity in terms of kinds and distribution. One may identify several use-phases: A descriptive phase, followed by a phytogeographic one, are the earliest stages in the herbarium "life cycle". In the descriptive phase, the emphasis is on the accumulation of representative materials of as many different taxa as possible from anywhere and everywhere. Some herbaria and their curators never evolve beyond this stage but in most, taxonomy grades into systematics and the growth of the collections has more direction both in terms of taxa and geographic representation.

The next phase of botanical taxonomy, the biosystematic, has its characteristic influences on the development of herbaria too, whatever the term "biosystematics" means to each of you. Population samples of the taxa under study are amassed in great quantities for such studies and while they may threaten to overwhelm the ordinary herbarium, these samples are surely valuable documentation materials, just as much as those in conventional herbaria. Obviously, however, there is neither space, equipment, nor caretaking available for such vast accumulations of what may appear to be "duplicates" in many instances. At the National Herbarium these vouchers for taxon variability are kept in files separate from the "regular" herbarium as a special collection, partly perhaps because no one

is completely certain whether to keep or discard them. Certainly they are not duplicates in the usual sense, one of several whole plants or parts of plants collected under the same collector's number.

The most recent phase in the development of plant taxonomy is what Shetler calls "ecosystematics" or ecosystem taxonomy. If it is not already clear that all these phases continue to coexist in the present, let me emphasize that point now. It is that just now, botanical collections, indeed all those of systematic biology, have the opportunity to serve new purposes in addition to those they have always provided for previously. In meeting the new challenges of ecosystematics, the herbaria have an enormously important opportunity to address many of the problems with which they have been grappling only partially successfully from the beginning. Although the time is ripe for new strategies, we are scarcely prepared to meet the needs that are with us even now. Change is so rapid that only the most innovative thinking will serve to ensure the herbarium the place in science most of us would like, that in which we are not required either to operate without adequate support or to be constantly grubbing-out only survival-level support. Let us look at some of the recently developed and future demands of herbaria resources which, if met, contribute to the effectiveness of plant collections and the people who tend them.

While not novel, strictly speaking, the use of herbaria in the search for new drugs and other economic plants seems almost a reversion to some of the earliest uses of collections. The U.S. Department of Agriculture has for decades carried on field and herbarium studies toward this goal and currently their global search for cash crops that might replace the culture of poppies and other drug plants in countries of the Near and Far East is an especially dramatic example. Herbaria as they are presently constituted are reasonably helpful to such efforts but data needs that cut across the ordinary organizational criteria (phylogeny and geography) of most herbaria are accessible only at great cost or, more often, not available at all.

It is in the field of environmental research that herbaria are excitingly challenged. The use of plants, phanerogams and cryptogams, to detect and monitor environmental change is a genuine prospect, if the associated data resident in the relevant collections can be extracted and organized for recovery. Such a use of collections is not unlike those with which we are somewhat more familiar, as for example the use of plants to indicate soil fertility, the presence of economically important minerals,

the presence of salt or other materials unfavorable to most plants, and the water content of soils. Some very interesting work has been done on the effect of air pollution on flowering plants, as well as some cryptogams, but most collections of phanerogams in herbaria have been made to avoid damaged foliage, so they may be somewhat less useful for tracing environmental degradation. On the other hand, such plants as the aquatic, unicellular, and colonial algae are most useful in that they are differentially affected by water pollution. Thus, the species composition at a particular site now and in the past, as shown by collections, may be highly significant for detecting the onset of water quality loss and tracing its history. Similarly, the distribution of lichens in industrial countries coincides precisely with the distribution of air-borne pollutants. It is reported that if one plots the distribution of lichens in some areas of Western Europe, the pattern of distribution of industrial pollutants is plotted simultaneously.

Still another use of herbarium collections is in a relatively new field, sometimes called landscape planning. Two botanists at Colorado State University, using advanced electronic equipment, have constructed a system for data control that is proving extremely valuable for management of the lands of that state. They collect information on the distribution of plant species and plant communities and plot these data electronically on base maps of the state. Then by superimposing plans for placement of new housing or new agricultural areas on plant distribution maps, it is possible to avoid serious mistakes and to make the best use of the lands for each of several purposes. Because many plants are sensitive to altitude, soil nutrients and water, etc., the potential impact of botanical data on long-range planning for the best utilization of environmental resources is a most important aspect of our botanical future.

One thing is sure, all these new and future uses of botanical information require sophisticated computer equipment and software technology. The major herbaria of the future will have computerized control of selected kinds of data, although not necessarily in each center on an individual, unilateral basis, nor will there need to be developed banks of all the data from all the collections in any herbarium. It is entirely practical and attainable, indeed mandatory, that segments of the total data represented in the principal botanical data centers be made available — for a price in both people-time and money. It is just as certain that not all the three-plus million plant collections in the National Herbarium or the New York Botanical

Garden will be mindlessly cranked into a data-bank, for there are probably at least half of all these that do not have appended data worth incorporating in any data-control system. On the other hand, we could be capturing data regularly from newly arriving materials in all the most actively growing centers. At the same time, these botanical centers should be prepared constantly to respond to the needs for latent data in the collections that can be made available when those who need the information are willing to pay for its extraction from the herbaria. This, like the need for identification and other taxonomic/systematic services, poses no real problems so long as they are budgeted for in advance. No longer can the taxonomic community provide any of these services as if they are not costly, as if they are of secondary importance to other sets of data for which people expect to pay.

The Flora North America Program illustrates very well indeed the kind of data-control system I believe is mandatory for systematic biology generally, if it is to have a vital role in human affairs of the future. Just as present arrangement of data in herbaria is unidirectional, the data presented in conventional floras, monographs, and revisions provide answers to questions that parallel their structure, but just try a question that requires search across the lines of organization of the data presented, questions such as which of the species grows with what others at x-1000 feet altitude and flower in June-July! Another kind of question needs asking — how long does it take to produce a definitive flora of a state, or of a particular phytogeographic province, even if the funds were available? Then at what cost the next edition of such a flora? An example of what I mean by questioning the cost of a second edition is provided by a current entomological project in the National Museum of Natural History. The names, distribution, etc. of the Hymenoptera were compiled in a catalog published by the Department of Agriculture in 1950. Now, after two decades of new research and data accumulation, specialists are no longer able to retrieve their information rapidly and a new edition of the catalog is being prepared using machine methods. Interestingly, the new edition will be produced more economically, but even more important, all the data in the catalog will be on magnetic tape where it can be corrected or added to as required. At any point in the future, the third edition or any part of it can be generated by the computer with minimal human attention at that point. This kind of capability is going to be needed in all areas of systematic biology, I am convinced.

The Flora North America as such a data-bank is an entirely viable concept. Once the existing information on North American plants is collected, collated, edited, and input to the data base, the possibility of answering many existing questions, including floristic treatments of various geographic, altitudinal, or phenological parameters will be semi-automatic. The taxonomist, rather than rearranging the data along still one more set of criteria, can be truly gainfully engaged in collecting new information and refining that existing in the bank. I am not presuming that this transformation will come quickly or inexpensively but it is unquestionable that the rate of publication of new information far exceeds the capacity of any of us to keep abreast of it. Will we use all the tools available to us and maintain our central role in addressing man's needs, or will we use only those that are familiar, those that satisfy the individual taxonomist's needs and the handful of his kind in the world interested enough in his work to request a reprint? The time to act with vision, with dynamic purpose is now. Even if we were concerned only with data from gross morphology and phytogeography, the time is now to find ways for more effective storage and retrieval of the facts. When we add to these, as we certainly must, the anatomical, embryological, cytological, and biochemical knowledge, taxonomists are more likely to be overwhelmed by the wealth of data than assisted in achieving improved understanding of evolutionary sequences and relationships.

These remarks are not intended to be an attack on either traditional publications or on the herbarium as an institution. What I am speaking of is an extension to the usefulness of both by the application of data-processing technology to enhance their information value for the present and future. Clearly, systematists generally must evolve better means to deal with the millions of specimens and to make better decisions about the necessity of collecting additional ones; to control systematic data gleaned from the collections in such a way that they may be rapidly compared with new data; and to make available the data in published form so that the efforts of each generation of systematists will be truly additive, rather than repetitive or of minimal importance. There is too much to be learned of the planet's plants and animals for systematists to waste one day, one word in unproductive investigations and the need to know far exceeds our ability even to accumulate the data. We are already coming to the point in many parts of science where it is simpler to redo a study than to discover whether it has been done adequately!

Lest someone concludes from my remarks that computers are the long-awaited panacea for all our problems, I want to emphasize that the need for good observations, sound judgments, and the other attributes of the human mind is not eliminated by the machine. Rather, the mind of man no longer needs to be cluttered by the inconsequential and it is thus freed for creative accomplishments at new levels. The taxonomist now is able, with this tool, to have access to any number of taxa, to discover new relationships and immediately associate these with those in the multi-dimensional data-base in storage.

The role of the herbarium and those who are its curators has been to bring together samples of the world flora, to arrange and conserve them, to conduct studies of the identities and relationships of the taxa the specimens represent, and to make accumulated botanical wisdom available to those who need it. In spite of dire predictions to the contrary, that most species of organisms will disappear before being known, there is greater need to continue taxonomic/systematic studies than ever before, but with a very clear new attention to those groups with the greatest potential for being important to man's struggle to adapt to new threats. The results may not enable us to be much more definitive about plant phylogeny but we may be able to preserve more of the earth's germ plasm in botanic gardens, arboreta, and other such live collections if we know it exists. Also, we may be able to preserve more of the aesthetic as well as practical aspects of our surroundings if we know them and their properties.

So herbaria and their curators have a well-defined, important role today. With imagination, innovation, and inspiration, herbaria, systematic collections generally, have an expanding, nearly limitless role tomorrow.

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Ornamental Plant Introduction— Building On the Past

It is a particular pleasure to participate in the Centennial Celebration of the Arnold Arboretum, not only because of the esteem with which we all hold "The Arnold", but also because of the fact that I have been assigned a subject to which I have devoted the major portion of my career — plant introduction and exploration.

As many of you know, plant introduction is a foundation stone on which a successful arboretum, botanic garden, or like institution, must build. Any one of the special activities that is encompassed by the broad term "plant introduction" can be an exciting program, whether simply exchange of plants and seed, the undertaking of actual field explorations, or the subsequent evaluation of introduced plants. The Arnold Arboretum has been deeply involved in all these pursuits and, because of its role in the introduction of new trees and shrubs and the explorations of E. H. Wilson in Asia, has often been called "America's Greatest Garden".

During the course of the past 100 years, the Arnold Arboretum has introduced more than 2,000 new plants, of which 60–70 are common in American gardens. The Arnold Arboretum is, of course, not alone in such activities, although during the early part of the 20th Century it was the Arnold Arboretum and the U.S. Department of Agriculture that were responsible for the majority of introductions through exploration. Today, many arboretums and botanic gardens are engaged in plant introduction, and there is no longer a single "greatest garden" but, rather, many great gardens share in the efforts to introduce new plants to the American public.

Although the USDA has been engaged in plant explorations since 1897 and has undertaken over 150 explorations, these have been mostly for economic crop plants. Early USDA explorers did not ignore ornamental plants when encountered, but only the Arnold Arboretum sent out collectors whose main objective was to collect ornamental plants. It is fairly safe to say that these two organizations have pre-empted plant ex-

Reginald Farrer

Frank N. Meyer

George Forrest
Photo: P. Popper

ploration for the United States, while English collectors have been in the same position in Europe. In 1956, however, the USDA, as a result of the cooperative Longwood-ARS program, assumed the leading role in ornamental plant exploration which I will discuss later.

The history of plant exploration since about 1900 is replete with incidents of high adventure, encounters with adversity and tragedy, often in the loss of valuable plants enroute, failures after plants had arrived, and, sadly, in the death of plant collectors in the field — Frank Meyer (1918), Reginald Farrer (1920), and George Forrest (1932) — all of whom met their fate in the China or Burma region. While it is the professional explorer who must receive the plaudits for his contributions to horticulture due to his authoritative role and, in part, to the better documentation of his collections, mention must be made of the missionaries, doctors, foreign service officers, and occasional travelers who accounted for many of our plant introductions. A medical missionary, Ralph Mills, collected the handful of seed of Korean Lespedeza (*Lespedeza stipulacea*) in 1919 that was the basis of this multi-million dollar crop. A missionary, A. S. Cooper, introduced the lot of seed of *Ilex cornuta*, P.I. 65860, from which the widely-used clone 'Rotunda' was selected. The USDA inventory states that he collected the seed near Ichang, China, in 1923. Those of you who are familiar with the travels of our Chinese explorers will appreciate that this was the principal starting point on the Yangtse River for journeys into western China. This lot of seed was sent to the McIlhenny Estate, Avery Island, Louisiana, where it was sown and the seedlings planted into a long hedgerow. From this highly variable introduction, nine named selections have been made. Another scarcely-known collector was the departmental pathologist, R. Kent Beattie, who traveled in Japan and Korea from 1927 to 1931 while studying chestnuts, particularly *Castanea mollissima* and *C. crenata*, for sources of resistance to chestnut blight. In addition to large shipments of chestnuts, he sent back a number of ornamental plants. But, chiefly, he should be remembered for the collection of some 80 evergreen azaleas that were used by B. Y. Morrison as parents in the development of the Glenn Dale azaleas. When I traveled to Japan in 1955, Beattie's notes on Japanese nurseries and the lists of rare plants he encountered there were most valuable since the nurseries still maintained many of the plants described by Beattie. Today, because of very strict international quarantines, limitations of where most people can travel in foreign countries,

and fewer opportunities to encounter unique plants, the role of the casual collector has all but disappeared.

I should now like to return to the professional plant collectors and comment on some of their journeys. The grand period of ornamental plant exploration began just prior to 1900 and continued up to about 1930. In 1899, E. H. Wilson set off for China on behalf of the English firm, Veitch and Sons. Before starting his field work, Wilson spent some time with the famous British medical officer, Dr. Augustine Henry. Henry was one of the most learned botanical collectors of the 19th Century, with years of experience in China, and was stationed at Ichang from 1882 to 1889. Wilson's two trips for the Veitch nursery in 1899 and 1903 netted a number of important ornamentals of western China, but chiefly his early trips are remembered for the introduction of *Davidia involucrata* and *Meconopsis integrifolia*. On Wilson's return to England, his reputation as a plant collector was established. Here begins one of the more intriguing developments in plant exploration of the early 20th Century.

David Fairchild, champion of plant exploration in the Department of Agriculture, was responsible for many of the Japanese economic and ornamental plants introduced into the United States. He arrived in Japan on April 26, 1902, but, according to his notes, too late to see the flowering cherries he had set out to collect. However, he traveled the length of Japan, sampling the curious edibles with enthusiasm. The margins of his field map are annotated with notes on interesting plant localities. During his journey, he noted the extensive use of *Zoysia japonica* as a lawn grass and sent the first introductions of *Zoysia* (P.I. 9299–300) to the United States, along with a collection of 18 bamboos and 30 varieties of flowering cherries. To David Fairchild we owe recognition not only for his own collections, but also for his sustained encouragement of the Department's plant exploration program in China, resulting in vast numbers of plant introductions that have contributed to American agriculture.

Charles S. Sargent, who had already been to Japan in the fall of 1892, was also determined to develop a leadership role for the Arnold Arboretum in plant exploration in the Orient. While Sargent spent only 10 weeks in Japan, his journey to Mt. Hakkoda was most rewarding. Not only must it have encouraged him to give primary attention to woody plant introductions from the Orient, but he introduced *Rhododendron kaempferi, Acer nikoense* in large quantity, and several mag-

nolias into the United States. It was here that he may have been encouraged by James Veitch to emphasize collecting in China. Japan for many years after was not intensively explored for ornamental plants.

Fairchild employed Frank Meyer, a Dutch immigrant, in 1905 to undertake extensive explorations in China. Meanwhile, Sargent was negotiating for the employment of E. H. Wilson, who finally accepted to collect in China for two years and hoped to return to become a member of the Arboretum staff. Meyer arrived in China in 1905 and concentrated on economic plants near Peking during the first winter, then moved down to the Yangtse River in the spring of 1906 and slowly journeyed northward during the summer as far as Manchuria and western Korea, collecting small grain cereals, forage crops, and soybeans. His shipments from northeast China included, as well, fruits with unusual hardiness and a number of shrubs and shade trees.

Wilson arrived in China in 1907 and met with Meyer in Shanghai on an arrangement between Sargent and Fairchild. Meyer explored the Lau-shan mountains and agreed to collect in the Wu-tai mountains, a rather desolate and disappointing region. Nevertheless, Meyer collected more than a thousand seed and plant specimens from North China and returned with a wealth of information on dry-land farming methods and other facts on Chinese agriculture. Wilson, meanwhile, traveled his familiar route up the Yangtse from Ichang and spent the next two years collecting in western Hupeh and Szechuan, from Cheng-tu across the mountains to Tatsien-lu, and covered the triangle formed by the mountains Wa-wu-shan, Wu-shan, and Omei-shan. Keep in mind that, although this was only a journey of less than 100 miles, the terrain was of such a dangerous nature it was indeed a remarkable trip and yielded more than 2,000 packets of seed and 1,400 living plants. Both explorers returned to the United States; Meyer in 1908 and Wilson in 1909. And both soon were back in the field; Meyer in central Asia in 1909 and Wilson again in China in 1910. The accounts of their further journeys are so familiar that I need not go into them here.

From the various letters and comments in books by and about Fairchild and Sargent, there was to continue an obvious amount of professional suspicion throughout their relationship. It is somewhat reflected in the attitude of Wilson and other collectors toward the rather morose Meyer. But I can find no similar attitude of his colleagues in the letters written by Meyer to Fair-

child. Indeed, Meyer's methods of collecting, with little attention to herbarium specimens and other supporting materials, his patient resolve to remain in the field in winter, and his attitude toward the Chinese customs, seem to have annoyed other collectors in China (see Farrer, R. *On The Eaves Of The World*, Vol. II:276–282. 1917). Herein Farrer describes, with his vivid flair for over-emphasis, his encounter with Meyer in the village of Siku, Kansu Province in 1914. It is one of the enjoyable insights into the highly complex attitudes that prevailed among these individualistic collectors. It must also be remembered that Purdom, who had followed Meyer on an equally unfruitful journey to Wu-Tai for the Arnold Arboretum in 1909, was now the traveling companion of Farrer during the 1914 expedition to Kansu and may also have influenced Farrer's opinions.

Despite their keen competition, these two very strong leaders (Fairchild and Sargent) did not permit their feelings to interfere with the sharing of introduced materials between the Arnold Arboretum and the USDA. This cooperation has continued through the century to the general benefit of American horticulture.

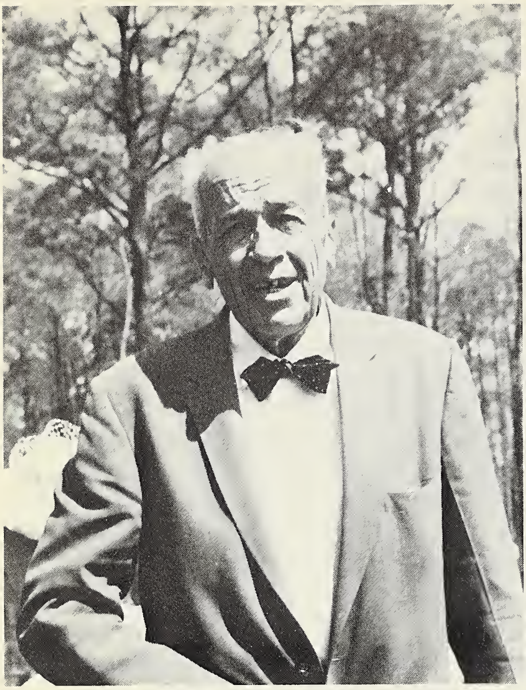
The fervor of plant collecting in western China peaked just prior to the First World War. No fewer than six well-known British and American collectors — Farrer, Forrest, Kingdon Ward, Meyer, Purdom, and Wilson — could be found attacking the great snow ranges of western China, up from Burma as seemed to be the route for Forrest and Kingdon Ward, or along the Yangtse River with Ichang as the starting point for Wilson, and the North China route for Meyer, Purdom and Farrer. Following the First World War Joseph Rock began collecting, first for the USDA in 1920 and later for the Arnold Arboretum and the National Geographic Society, until 1934. But now, Meyer and Farrer were both dead and Wilson had left off field work, leaving Forrest and Kingdon Ward to continue collecting. Kingdon Ward was the only one of this group who carried on into contemporary times. His field work exceeded 40 years and the amazing record of 23 expeditions. Few, if any, more recent collectors of note of ornamental plants can be added to this list. Fairchild did, however, continue his travels in the 1920's and 1930's to Europe, Africa, and South America, expounding on the importance of plant exploration and encouraging others to collect. The USDA continued in its collecting of economic plants and sent 38 exploration teams into the field between 1930 and World War II, and many of these collectors sent home ornamental species.

Time does not allow for a discussion of the many introductions of plants obtained during the first 40 years of the 20th Century that survived the rigors of climate, war and depression, and horticultural acceptance to become important nursery plants. These are well documented in horticultural literature. As for plant exploration, an era was at end. No longer would explorers roam remote places on trips of several years' duration and the methods of collecting and shipment would be sharply changed by the advent of plastic films and the airplane. As for China, it was thought that the cream of the species had been collected already and there was little reason to continue interest in that country. But it should be noted that this same opinion was voiced prior to the explorations that began the 20th Century.

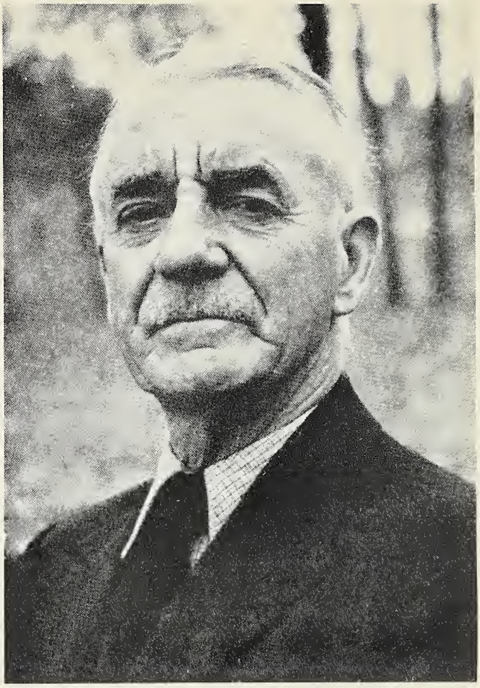
The present era of plant introduction opened with a resounding discovery. *Metasequoia glyptostroboides*, previously known only from paleobotanic records, was discovered in China as a living species in 1945. Following this lead, the Arnold Arboretum promptly supported an expedition to the locality on the Szechuan-Hupeh border. As a result, a limited stand of about 1,000 trees was discovered in the Shui-sa-pa valley in Hupeh. Seed from this find was widely distributed by the Arnold Arboretum in 1948 and seedlings became established in almost every suitable locality around the world. I first reported on the rooting of *Metasequoia* from juvenile cuttings in 1948 and the National Arboretum selected and released a clone, 'National', in 1963 from P.I. 16188. This came from seedlings growing at the National Arboretum as the result of a shipment of seed sent from the National Central University, Nanking, to the USDA in 1948. I believe no species received as wide and as rapid a distribution around the world as was the case of *Metasequoia*.

The finding of *Metasequoia* in a locality not far from where many early explorers had worked rejected the concept that the enormously rich flora of China had been sampled to the point of diminished returns. The opportunities to find new forms and more useful variants of ornamental plants in China was as promising as at any earlier time.

During the first several years after World War II, arboretums that received scant support prior to World War II, such as the National Arboretum, began to progress markedly. Their interests turned to the evaluation of the many early introductions now reaching maturity in our arboretums, botanic gardens, and other test localities. A broader interest in horticulture resulting from the development of suburbia caused horticulturists



B. Y. Morrison



F. Kingdon Ward

Photo: J. E. Downward

to look for better and different types of trees and shrubs. Dr. Donald Wyman provided outstanding leadership in this research evaluating hundreds of species and varieties trying to develop lists of those with the best qualities. Others followed this same approach. For example, when Frank Meyer collected seeds of *Pyrus calleryana* in China, his main purpose was a source of fire-blight resistance. The ornamental possibilities of this species were not even considered. In 1952 I selected a tree from the few specimens of *P. calleryana* remaining at the U.S. Plant Introduction Station, Glenn Dale, Maryland, grafted it onto *P. calleryana* seedlings, and established the trees in a nearby subdivision for a street tree study. Over the ensuing years, this selection has become more and more popular and the USDA named it 'Bradford'. Today, the 'Bradford' pear is regarded among the top ten trees for street planting in eastern United States. But it is limited in its cold-hardiness. Perhaps a search of its native Chinese homeland will locate additional germ plasm for evaluation. This species, it is important to note, was first introduced into the United States in 1908 by E. H. Wilson.

Ornamental exploration had yet to fully recover from the War years. Kingdon Ward was back in the field and conducted six explorations in the Assam-Burma area between 1946 and 1957. The Royal Horticultural Society and the Japanese sent teams of explorers to Nepal in the early 1950's. In the United States a new concept of plant collecting resulted from the 1946 Research and Marketing Act. It gave support to foreign and domestic exploration on a sustained basis. Previously there were few Federal funds for explorations, and no mechanism to provide for inputs by States and others in determining priorities for exploration. Under the new Federal/State cooperative program plant explorations became mission-oriented with emphasis on collecting to fill the gaps in our germ plasm base of specific crops. General collecting became a thing of the past. In addition to introduction activities, this program provided for four regional introduction stations — Geneva, New York; Ames, Iowa; Experiment, Georgia; and Pullman, Washington. Later a special inter-regional potato station was established at Sturgeon Bay, Wisconsin, and in 1958 a National Seed Storage Laboratory was established at Fort Collins, Col. to house our genetic resources under optimum conditions for long term storage.

Provisions were also made for domestic explorations, taking advantage of the many experiment stations and their scientific staffs to conduct the field work. Since 1953, 39 such collecting trips have been made, of which 9 have been for native ornamental plants, including rhododendrons, junipers, mountain ash, and ground covers. While the principal objectives of the regional stations were preliminary evaluation, increase, and distribution of plant introductions, some ornamentals were tested on a regional basis and released as named varieties. 'Cheyenne' privet, P.I. 107630, collected by Edgar Anderson during an Arnold Arboretum exploration in Yugoslavia in 1934, was introduced into the trade because of its superior hardiness in the northern Great Plains. A sweet basil (*Ocimum basilicum*) collected in Turkey during a field crop expedition in 1949 was named 'Dark Opal' by the Connecticut Agricultural Experiment Station because of the purple coloring of foliage and flowers. It received the bronze medal in the 1960 All-America trials.

Despite the profound effort at organized introduction of economic crop germ plasm, ornamentals did not share in the support. Quarantine laws had been tightened and many of the ornamental trees and shrubs previously imported from Europe

were prohibited. This was unfortunate in that arboretums like the Arnold, Morton, National, and University of Washington were renewing their activity in assembling clonal material from European sources. In order that new material might reach the U.S., the Arnold Arboretum proposed a program to the USDA in 1953 whereby restricted plants already known to be in the U.S. would not be re-introduced. Rather the Arnold Arboretum would act as an "agent" for other gardens, and evidently "new" plants would be shipped from Europe to the Plant Introduction Station at Glenn Dale, Maryland, for quarantine. After the required 2-year quarantine, the plants were then released to the ordering institution and propagated for other gardens. Individual botanic gardens and arboretums also searched European nurseries for non-restricted plants and these have continued to be introduced in order to fully understand the variation in our ornamental species and to locate improvements over current cultivars.

Perhaps the most significant event in modern ornamental exploration was the initiation of the Longwood-ARS program in 1956. Recognizing that current Federal programs did not include ornamental collecting, Dr. Russell Seibert proposed that ARS enter into an agreement with Longwood Gardens to collect ornamentals on a sustained basis. For the first time public and private institutions were joining forces to meet the needs of the gardening public by collecting wild and cultivated plant materials in the fashion of the early explorers. In order not to conflict with other efforts, the Longwood-ARS program concentrated on regions of the world where exchange of plants and seeds could not be easily accomplished; it supported explorations to centers of origin of important ornamentals, and provided for a thorough survey of botanic gardens and nurseries of Europe for improved varieties otherwise not available to American horticulture.

Thirteen explorations have now been completed under this program. Of these, 9 collecting trips have been to Asia, virtually ringing mainland China. The two most recent were the New Guinea exploration by H. Winters and J. Higgins in 1970 and my own journeys to Siberia in 1971. Materials collected on all these explorations are shared with experiment stations, botanic gardens and arboretums, and the nursery trade as rapidly as possible. For example, a large group of *Impatiens* collected from the 1970 expedition to New Guinea has already been released to growers. These have created considerable excitement by their striking range of flower color and variation in form

and foliage. This material will be the basis of new cultivars for the commercial trade and, in addition, will provide a wealth of germ plasm for breeding programs.

With this rich history of plant collecting by various institutions and the success achieved in the evaluation of plant introductions, it is now time to look to the future. In relation to economic plants, there is a broad collaborative effort underway under sponsorship of a consortium of international agricultural institutions to develop a global network to collect, evaluate, and conserve genetic diversity around the world. There is evidence that our world's genetic resources of crop plants are being displaced, depleted, and, in the case of some collections, discarded. As a result, priorities for crops and geographical areas have been defined by experts in plant genetic resources for immediate action. Inventories are being developed of the total holdings of collections of crop germ plasm. Despite an inventory of over 2 million items reportedly held by various nations, an FAO survey showed that only 28% are under secure conditions to assure their survival. These are largely in the U.S., USSR, and a few other developed countries. There will be an attempt to place the bulk of our genetic resources into major regional storages before they are lost. The need for immediate action is readily understood.

These programs do not include ornamentals since it is assumed that the various associations devoted to ornamental horticulture will develop their own program. These could very well be along similar lines to those proposed for economic crops. Already the American Horticultural Society is moving forward with its Plant Record Center to document living collections in the U.S. The Longwood program is providing for a long-range plan for exploration and, as discussed earlier, a system has been developed by the Arnold Arboretum to introduce plants normally prohibited from entry. Perhaps our weakest link is lack of a nationally coordinated program for evaluation of new ornamentals and a system of regional testing of superior selections for adaptation. There are some instances of this, but not on a major scale. In the North Central States there is a cooperative regional testing program underway among States and Federal institutions. This began in 1954 and provides for performance trials of selected ornamentals with respect to established criteria: survival, growth, freedom from pests and diseases, pollution resistance, and characteristics of foliage, flowers, and fruit. The results of these trials, reported on a 5-year basis,

provide scientists, nurserymen, and home-owners with reliable information on potentially new ornamentals.

As for plant exploration, we are all aware that the future is on the Chinese mainland just as it was at the turn of the Century. The advent of air travel and access to areas previously unattainable because roads did not exist offer opportunities for collecting beyond what was accomplished by early explorers. In addition, new information gleaned from the ensuing years of evaluation, plant breeding, and taxonomic research provide us with useful priorities for future collecting trips.

The hollies of Eastern Asia, numbering some 120 species, illustrate this point. Although China is especially rich in species of *Ilex*, we know many of them imperfectly because of the few introductions. A similar situation had existed with the species native to Japan, but it is now somewhat improved. Since 1956 a broad base of variability of the major Japanese species, *Ilex crenata*, has been introduced under the Longwood program. Over 50 collections of *I. crenata* representing its total range of distribution in Japan have been introduced and distributed. Seed lots of 14 other species and natural hybrids were introduced for the first time during this period.

One of the very interesting research findings in relation to Chinese species of *Ilex* is the naming of a new species, *Ilex centrochinensis*, by Dr. S. Y. Hu of the Arnold Arboretum. Long confused with *I. ciliospinosa*, this new species was first introduced from China not far from the locality where *Metasequoia* was discovered. The importance of this species has been its usefulness in crosses with *I. cornuta*, from which some remarkably fine hybrids have been produced. Since there probably has not been a single wild collection of this particular species introduced under its own name during the last 50 years, it offers a challenge to the future collectors in China. Equally significant information could be developed for other Chinese holly species, i.e., *I. cornuta, I pernyi, I. rotunda*, and *I. yunnanensis*, and for many other plant genera. Just as for economic crop species, ornamentals are threatened with eradication and because of their lower status are usually the first to go when land is diverted to other use. Species diversity, and finally the species themselves, disappear as a result.

As far as future plans for collecting in China are concerned, we might develop various levels of exchange programs such as have been in effect between the U.S. and the USSR since 1959. This initial exchange of seeds and plants on a *quid pro quo* basis developed into a mutually satisfying arrangement,

leading to four explorations of the USSR since 1963. We know very little about current germ plasm activities in China. It has been estimated that there are over 200,000 accessions of some 50 crops in Chinese collections. This is about the extent of the collections held in the U.S. and in the USSR. Probably a considerable amount of attention has been paid to ornamentals judging from earlier exchanges that took place between Soviet and Chinese botanic gardens. With airports at Cheng-tu, Szechuan, Kun-ming, Yunan, and development of modern roads in Western China, a new and equally rewarding phase of plant collecting in China may become a reality with exchange and exploration initiated simultaneously.

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The Botanist and the Computer

Modern taxonomic botany has changed little from its descriptive origins in the 18th century. With the modern understanding of the plant as a living system and its place in the larger system around it, our descriptive efforts have changed to place the plant in context and not simply consider it as a dried specimen on an isolated herbarium sheet thousands of miles from its origin. In spite of this, however, our science has remained largely a descriptive one, and perhaps it is the pressure of our own needs, plus the pressure from our academic companions in other fields, which has caused us to look to a more mathematical approach to botany. The advent of the computer was a natural beginning to numerical processing of taxonomic data. From initial enthusiasm about ten years ago for numerical taxonomy [1] as the cure-all for taxonomic problems, we have now settled down into a more reasonable and wider use of computers in the field of botany. For many botanists, this early enthusiasm was entered into without a thorough understanding of the tool which made it possible. Today, with 30 years of computer experience behind us and perhaps some ten years of botanical enthusiasm in the same area, we are in a position to look at the equipment available and to evaluate the potential and the pitfalls of the computer as a new tool in the botanist's laboratory. We must, however, recognize that the computer is only a tool and not in itself a solution to the problems of botany. The computer can be used by the botanist only to the extent that he is logical or mathematical in his approach to problem solving. The past literature of botany, which is the data bank of the science, has already grown to such an extent that it is a nearly impossible task to extract from it all the pertinent facts relating to any given taxon. With the number of botanists working today, the situation will continue to worsen unless we start now to logically orient our facts and to place this logical assemblage into a machine-readable form which will allow us to search it and process it as the needs of the individual scientist require.

In recent years there has been an increasing quantity of literature built up relative to the use of computers in the broad field of biology. It is not the purpose of this paper to review the applications of computers to specific problems. This has been done

in part by Crovello and MacDonald in their index of EDP-IR projects in systematics,[2] and also has been covered to a great extent by the papers reported in the *Biological Journal of the Linnean Society* in September 1971.[3] It is the purpose of this paper to present some of the basics of computer operations and the effects they must have upon the approach to botanical problems if proper use is to be made of this new tool. Those persons who have not taken up the new world of computers often continue to shy away from, and in some cases even to fear, the unknown. Many others who have become absorbed in this new technology have often gone to the other extreme and completely masked the products of their efforts in a foreign jargon which has served only to increase the gap between the users and the non-users. This paper is an attempt to both slay the dragons and to bring the prophets back to earth for the greater number of botanists who have remained until now on neutral ground. The central theme of this discussion is that the computer is simply a tool, and in no way is it an end unto itself. The problems to which this modern tool may be applied are not unique to modern thinking, nor does the use of this equipment mean, of necessity, the abandonment of familiar procedures and techniques. On the other hand, a proper comprehension of the potential use of the new tool can lead to entirely new approaches to old problems.

Perhaps it is best to start by looking at what a computer is and what it can do in the abstract. In its most fundamental form, a computer is a machine that can execute simple logical commands. It can be made to compare two sets of data and, based upon the result, can embark upon one or another of a set of previously determined courses of action. In its simplest form, the computer is not a mathematical machine, but it is as a consequence of specific series of logical operations within the machine that various mathematical operations are carried out. Computers in themselves exhibit no intelligence, and it is unfortunate that the anthropomorphic view of these machines has become the popular one. Problems cannot be solved nor questions answered except to the extent that a previously anticipated answer or course of action has been selected as the correct solution based upon a logical and previously determined analysis of the data in hand. In a perhaps over-simplified sense, what computers are best suited to do is to carry out a relatively simple manipulation in a repetitive fashion upon a large body of data. Alternatively, they can also be utilized to process a fairly complex series of operations on a relatively small quantity of data,

but since the operations must all be previously carried out by hand (*i.e.*, programmed), a decision must be made as to whether it is worthwhile to spend the programming effort necessary for a relatively low degree of utilization of the computer.

An early and continuing area of misunderstanding has been the supposed numerical nature of computers. Whereas most computers have been designed for the solution of numerical problems, there is nothing inherent in the nature of the machine which prevents representation within it of alphabetical characters. The concept of numericlature as opposed to nomenclature is both unnecessary and undesirable. The early mechanical limits of fixed field from a punch card origin, and of numericlature as a means to conserve storage space within the computer by codifying otherwise lengthier conventional language statements, have been two facets of the early use of computer techniques which have imposed unnecessary and unfortunate procrustean limits on data processing in botany. These initial difficulties, augmented by an unnecessary jargon and a number of unsuccessful projects initiated primarily in the name of fashion, have led to a slow start in the use of computers within the field of botany.

Before going on to some of the possible advantages of computer utilization in the botanical area of activity, it is perhaps best to digress momentarily in order to discuss a matter which is basic not only to the utilization of computers but in many ways to science itself. Consideration of the broad spectrum of biological problems in light of possible solutions by computer means is, in effect, a consideration of the design of experiments. Perhaps one of the most critical areas in botany in this regard is the general field of taxonomy. Classical taxonomy has, since the time of Linnaeus, been rather in the nature of an art, in spite of all protestations as to its scientific status. The questioning of such status comes not from the end result which has stood the test of time well, but from the manner in which the decision is arrived at. In the physical sciences, an experiment can theoretically be conducted by anyone if the conditions and the equipment involved in the experiment are stated, and if this set of conditions and equipment can be duplicated. Given the same data and the same procedures, the same results should be obtained. What has been lacking in botanical taxonomy and, in fact, in taxonomy in general, has been the specific designation of the parameters involved in any given "experiment". It was precisely the rigidity of such re-

quirements which led to the early misunderstanding, apprehension, and derogatory comment upon the use of computers in botanical taxonomy. It is not, however, the computer which is in question in such circumstances, but the statement of the experiment itself. If the taxonomist is not able to precisely define his terms and with equal precision to define the steps by which he arrives at a given conclusion, then he is unable to describe the experiment. If such parameters cannot be precisely determined and defined, then it is not possible for other individuals to consistently arrive at the same conclusion, given the same starting point. Recent work in the computer construction of identification keys and in random access identification queries in on-line computer systems have shown that the unforgiving taskmaster, the computer, can considerably simplify the task of identification if the logical processes by which a specific identification is reached are rigidly stated.[4]

The complexity and redundancy of the human mental process, while it is yet to be mechanically duplicated, can be more fully appreciated today than in the recent past. The capability of visualization without apparent quantitization was apparently unique to the human mind. It is now certain, however, that the neuron of the human brain is comparable to the single flip-flop of the computer, but both are meaningless except as they participate in the larger context of the total machine system. The process of learning in the human being is directly comparable, in part, to the building of a data bank in the computer. Furthermore, the learning process consists of considerable reprogramming which, as anyone who has worked with large data banks finds, is also a necessity as one develops the uses of the stored information.

In many fields, such as computer design and chemical engineering, considerable effort has been expended in utilizing the computer both as a design tool and as an automatic means of control. In many cases where the problem has been reduced to a machine-soluble form, it has been the repetitive nature of the task which has lent itself to successful computer application. In other instances, however, the rigid test of logical statement that must be met before the problem can be reduced to computer solution has often times been sufficient in itself. That is to say, that having reduced the problem to a logical statement, it was no longer a problem and could be solved without the use of expensive computer equipment. It is precisely this rigid evaluation of logical processes with which the botanist is now faced, and it is in this context that the problems of botany must

be stated. A careful distinction must be made between the problems and their potential solutions utilizing current technology. Too often the question is asked, "How can I use the computer to solve my problems?", in situations where the problems themselves have not been stated. While it cannot be denied that some of the solutions to botanical problems, particularly those involved in the curating of large collections or extensive literature search, are possible only because of the potential use of computer technology, it should not be presumed *a priori* that such problems will only have their ultimate solution through the application of computer systems. If the botanist can develop the ability to ask himself what he wants from his data without burdening himself with the seeming limitations of his present technology, the solution can ultimately result in considerably expanded horizons. This has been particularly significant in the statistical handling of biological data. Many of the techniques of such statistical evaluation, some of which have been unfortunately labeled as a sub-science of numerical taxonomy, are really only mathematical manipulations of data which could be done equally well with pencil and paper, but unfortunately could not be carried out in that way on a large data set within a reasonable period of time. The computer as a tool has allowed the statistical technique to expand, but statistics and computers are not synonymous.

Whereas the advent of computers has offered a wider horizon to the botanist for the potential solution of previously unsolvable problems, this potential, in itself, is not the only basis upon which a decision for computerization can be made. A realistic evaluation of the utility of any information retrieval system or statistical evaluation must be made on a basis of the value of the net result without consideration of the means of possible solution. If the end result is justifiable, only then can the means of reaching that end be evaluated. The distinction must be clearly made between the organization of knowledge and the mechanization of that knowledge. In this respect, a realistic evaluation of time and cost for the solution to any given problem must be considered. The high internal operating speeds of modern computers are impressive statistics. The fact that data can be manipulated within the computer in fractions of a second is not a realistic statistic when evaluating the true time from presentation of the data to the availability of the solution to a given problem. The true solution time includes all that time which is involved in the entry of the raw data, all of the delays and waiting periods in submitting the problem to the

computer (and the programmer), and in ultimately receiving the printout or other output from the computer. In a practical sense, what is often spoken of as microseconds of response can, in fact, represent weeks of waiting time for the individual botanist. In a similar manner, costs must also be evaluated. Can the expense of direct communication with a computer data bank be justified for information which is needed for a paper to be presented next month? The identification of an unknown plant by carrying out a question and answer session at a computer console is an impressive application of the computer, and, in fact, the random sequence in which the pertinent characteristics may in some cases be presented to a computer is a considerable improvement over the dichotomous key. The questions which must be realistically asked, however, are, "How much does it cost?" and "Is it worth it?" In small systems operating in small computers, the cost may seem reasonable, but when larger data banks are involved and consequently larger computer systems, the cost can quickly get out of hand. For direct communication with the computer, the data which are being referenced must be kept in a readily accessible storage medium. Even the least expensive of these can cost in the hundreds of dollars per day, while the most sophisticated high speed systems may run into the thousands of dollars per day for a data bank equivalent to the information content of a one-volume printed flora. As one who pays a rather healthy monthly computer bill for the operation of my own research projects, I have strong feelings that an unrealistic approach to botanical problems is presented in instances where major data banks are proposed on a large-scale basis without realistically evaluating the true costs of immediate availability. Realistic operating times and ultimate costs must be evaluated in the context of the true need of the user. This aspect of computer utilization has become most critical in recent times with the introduction of on-line terminals and time-shared computers. Can the individual scientist really justify the true costs of direct communication to a computer data bank as compared to looking up a similar piece of information in a more conventional reference work? This question must be asked each time one goes to a computer for the solution to a problem.

Oftentimes the on-line system is considered justification because of the supposedly random nature of the access need of the user. Critically evaluated, such access is too often not truly random but is limited to a finite number of rearrangements of the data. It must be remembered that the computer has not

only changed the mode of communication in terms of on-line access to stored data banks but has also greatly amplified the communication which is possible with the conventional printed word through the availability of permuted indices. By using computers for the preparation of multiple indices to a given reference work, the same ease of access that is available in an on-line operation can be made available in a printed report. In our own work, the preparation of a complete title index for a file of bibliographical references having more than 25,000 entries took only three minutes of computer running time. Actually, it took closer to a week in terms of response time from conception of the need to ultimate receipt of the print-out. Having once prepared this permutation of the data, however, it is now available on a direct access basis at a speed equal to that of an on-line computer inquiry, and, I might add, at a considerably lower cost of operation. When truly evaluated in terms of the total context of programming and equipment cost versus the time and effort required to manually look up a set of facts in a computer-prepared index to a data set, the justification for the use of on-line computer systems is difficult. The index which we prepared could not have practically been completed by other than computer means, but the off-line mode of operation was sufficient for our needs and continues to be so.

The preparation of multiple indices by computer means brings out still another aspect of the need for proper preparation and analysis of problems before entering into the computer operation. While the computer is particularly well adapted to searching large quantities of data for a particular set of facts, this search is made by comparing the information content of the body of data being searched against a standard which is the item being searched for. Comparison of two items to determine whether or not they are completely alike in every detail is a characteristic ability which is inherent in the computer hardware. Comprehension of the significance of two items which are functionally the same but which are stated in a different manner is not a built-in ability of computers. Such comprehension must be programmed and is one of the most difficult types of logic to program.

Thus, it becomes essential in preparing information for computer analysis that such information be presented in an absolutely consistent form in all cases. Such simple variations as an extra space or an incorrectly placed period are as different to the computer comparison as an entirely different word. If such variations are to be disregarded, the instructions to dis-

regard them must be specifically programmed into the computer. The solution to this problem is a simple one: consistency. This, however, is not an easy thing to achieve, particularly in an endeavor which extends over a long period of time. The preparation of indices requires the searching out and bringing together of all of a like item. Achieving this without programming comprehension into the computer can be done to a great extent by specifically identifying each particular type of information in each record. This "data language" is the responsibility of the individual botanist, and consequently data banks have the disadvantage, unlike museum specimens, that the information which is stored in the computer is already biased upon entry. If, however, the data are entered into the file in a consistent format and adequate recognition is given to the specific information units within the data and the potential extent of any piece of data, then for any given processing of the data the entire record need not be searched. Only that segment of the record which contains the specific information being sought must be processed. In more every-day terms, this simply means that the format in which data are presented to the computer must be rigidly adhered to, and that considerable attention must be given to this format before any data recording is begun. Only in this way will maximum utility of the data bank be possible for future needs.

Another problem facing the individual botanist when using computers is that of compatibility. Actually, this involves three separate and distinct problems in data processing. Machine compatibility is the ability to enter data automatically into the computer file. In its most acceptable form, the data should be able to be entered into the file without the need for human intervention. Recording the shape of the leaf scanned by a computer input device is, for all practicality, still a dream of the future. The more practical entering of numerical data from mark-sensed cards is a direct machine entry procedure. The capability of entering literature files, such as *Index Kewensis*, by means of direct optical character reading is a rapidly developing technique of the present. For the taxonomic botanist, however, most of the data which he will need in the computer file must be entered manually, and only after this manual data processing will a machine-compatible form of the file exist. The second type of compatibility is that of the data bank itself. While there are various formats for internal storage use in different computer systems, the transition from one format to another is almost always possible by direct computer processing,

and thus the data file compatibility is not a major concern, so long as the specific items of information which are stored in the file are analogous to any other file with which the data are to be utilized. This is not a new problem to botany but one which must be squarely faced if the botanist is to use a computer. Classification systems, based on the shape of leaf in one plant and the color of flower in another, do not lend themselves readily to the impartial comparison of a computer data file. Finally, the last level of compatibility is program compatibility, and this involves not only the operating programs which process the data but also is unfortunately tied closely to the individual hardware systems in use. The plea for compatible programs which can be exchanged between scientists is regrettably somewhat premature, considering the developmental stage of the computer industry. Computers began from a standing start at the end of World War II and now number in excess of 100,000 machines in use. The technology began with operations taking tens of milliseconds, and now has developed into operations described in nanoseconds. The hardware has developed from relatively small computers occupying the entire space of a large building to highly sophisticated computers occupying little more than the volume of an average television set. The development in this industry is not over, and with the rapidity of advance comes inevitable change. For the foreseeable future, true program compatibility is something to be sought but hardly to be achieved. What approach one uses to compatibility of programs depends in large part on which of two basic approaches to programming are utilized by the individual worker. If your computer needs are sufficient to maintain your own programming staff, then one can be relatively independent of changing hardware specifications, since new programs can be written to meet current needs and old programs can be modified as necessary. If, on the other hand, the computing needs are small and one uses the packaged programs which are available with most commercial computers, then one must be careful in this rapidly developing industry to choose a manufacturer who will provide a reasonable degree of stability. As a general rule, the more interchangeable the program, the longer the running time of that program in the machine, but here again, the true costs of using a computer must be evaluated, not in the simple running time of the computer, but in the total concept of the staff and equipment necessary to process the data.

If the botanist is to use the computer well, he must understand the processing of his problem in the computer. He must,

in essence, be able to program his own problems. Significant uses of computer data sets will come only from the individual who himself fully comprehends the abilities of the processing equipment. If the botanist is completely dependent upon another individual to provide programming, then he will be able to derive advantage from the computer only to the extent that he is able to state his problem in terms of the computer's ability. Programming has unfortunately become synonymous with the operation of translating the logical solution to the problem into the specific commands to be given to the computer. In reality, the most important part of programming is the ability to state the process of problem solution in simple logical terms. This is analogous to considering a skilled translator as equivalent to a talented novelist. The knowledge of the words of a language is not the same as the ability to use that language well. The botanist who does his own programming will soon learn to make the distinction between these two facets of the job. Whereas most university programming courses are exactly equivalent to university language courses, the course, Computers in Biological Systematics,[5] which is now offered at Michigan State University, is much more comparable to a course in composition and writing of a foreign language. Both knowledge of the language and fluency are necessary, but ultimately the latter is essential to the successful use of this new tool. A recent paper by Cutbill,[6] on new methods for handling biological information, should become required reading for any botanist involved in computer data processing.

In closing, I should like to say that the computer offers the botanist the means of coming from the 18th century into the present, but in order to do so, a retraining program is required so that the individual botanist may become completely familiar with the abilities of the computer and fluent in its language.

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Plant Ailments

Plants, like man and animals, are subject to myriad diseases. Moreover, there is no single kind of plant that is not affected by some disease.

Plant ailments are older than man. We know this because fossils that predate man's appearance on earth show evidence of such ailments.

As long ago as 700 B.C. man attempted to control plant ailments. The Romans later instituted the feast Robigalia to appease the rust gods with prayers and sacrifice.

In 1660, nearly 200 years before the true nature of wheat rust was known, a law was passed in Rouen, France, requiring the eradication of barberry in order to control rust. At that time some connection between the rust and the shrub had been established but it was not known that barberry was an alternate host of the fungus. Later, in 1726 and 1766 several New England states passed laws to suppress the spread of the common barberry.

Development of the science of plant pathology in the United States in the past 100 years parallels the development of botanical gardens and arboreta.

For some years the federal government maintained a commissioner of agriculture under whose jurisdiction were several divisions, including the Botanical Division. A section of Mycology of this division was established in 1881, and F. Lamson Scribner was appointed as the mycologist, with Erwin F. Smith as his assistant. This represented the first official recognition of the science of phytopathology in the United States, for the work had to do primarily with the diseases in plants.

The early research on plant diseases was conducted largely by federal and state plant pathologists.

In 1881 T. J. Burrill in Illinois demonstrated that the fire blight disease of apples, pears, and other members of the Rosaceae is caused by the bacterium *Erwinia amylovora.* Ten years later M. B. Waite proved that bees and wasps could spread the causal organism.

In 1912 passage of the Quarantine Act officially prohibited the importation into the United States of certain plants and soils

in a belated attempt to reduce the possibility of introducing pests and diseases from other parts of the world. By this time the white pine blister rust fungus had already been introduced on low-priced pine seedlings from Europe.

Today, more than 35,000 different diseases affect our economic plants — those used as food, feeds, fibers, and lumber. The number of known diseases of wheat in the United States, for example, is conservatively estimated at 100; of apple at 125; and of potato at nearly 100.

Nor are such large numbers of ailments confined to plants producing food, fiber and lumber. Shade and ornamental trees and shrubs as well as flowers are also subject to many diseases.

The average annual loss from plant diseases in the United States is estimated to be between 3 and 4 billion dollars.

Causes of Plant Ailments

There are two major causes of plant diseases — nonparasitic and parasitic.

Among the nonparasitic causes are mineral deficiencies, chemical injuries, and unfavorable water relationships.

Mineral Deficiencies. All plants need a balanced diet to do well. Those grown in soil which lacks one of the so-called major elements — nitrogen, phosphorus, or potash — or one or more of the essential minor elements, such as iron, boron, or magnesium, will not be normal.

The foliage of rhododendrons, mountain-laurel, and andromeda (*Pieris*) may turn yellow (chlorotic) because of a lack of available iron, which may, in turn, be due to excessive lime. This commonly occurs when these acid-loving plants are planted near a cement wall. Many trees, including pin oaks, cottonwood, boxelder, and sweet gum (*Liquidambar styfaciflua*), also become chlorotic because of the unavailability of iron. Incorporating a so-called iron chelate into the soil or spraying it on the leaves helps to overcome such a deficiency.

Chemical Injuries. Faulty application of nitrate, of potash, or of acid or alkaline fertilizers often brings on symptoms similar to those caused by parasitic organisms. If an excess of sodium nitrate is supplied during dry weather, for example, the foliage at the tops of the plants becomes brown and appears scorched.

Careless use of weed killers also may result in severe damage or even death of trees and shrubs. Weed-killing materials containing arsenicals or the hormone 2, 4-D should be used with extreme care.

Rock salt (sodium chloride) scattered over sidewalks or along

roadways to melt ice and snow or prevent water from freezing also causes severe damage to plants growing nearby.

Trees and shrubs growing along large bodies of salt water are often injured by wind-blown salt spray. During hurricanes the spray can actually damage foliage 50 miles from salt water. Smoke emanating from chimneys of manufacturing plants, apartment house incinerators, and other instruments of combustion, including automobiles, contains ingredients which are harmful to vegetation.

The three major pollutants released by manufacturing plants are sulfur dioxide, fluorine compounds, and the smog typical of urban areas. Maple and other broad-leaved trees exposed to high concentrations of sulfur dioxide, for instance, show ivory-white markings, mostly between the main veins; whereas Douglas fir and ponderosa pine exhibit a reddish discoloration of the needles followed by a shriveling of the affected tissues.

Unfavorable Water Relationships. A deficiency of moisture in the soil may result in the scorching of leaves. In such cases the leaves wilt when water lost through transpiration cannot be quickly replaced. Winter injury of broad-leaved evergreens occurs, for example, when the leaves lose more water than can be replaced via the roots while the soil is still frozen in late winter or early spring. In summer, the blossom-end rot of tomatoes is caused by a combination of insufficient moisture and a deficiency of calcium in the soil.

An excessive amount of water in the soil is another non-parasitic cause of some plant ailments. Yews (*Taxus* spp.), for example, are extremely susceptible to an overly wet soil. Research at Rutgers University revealed that yews could be killed by immersing their roots in water-saturated soil for 32 to 64 hours and then drying out the soil.

Parasitic Causes

Fungi, bacteria, nemas (nematodes), and ultramicroscopic entities known as viruses and mycoplasmas are the five parasitic causes of plant ailments. The last, mycoplasmas, are half way in size between viruses and bacteria. Some diseases such as aster yellows and witches' brooms formerly thought to be due to viruses are now known to be caused by mycoplasmas.

Let me briefly review the history and present status of some of the more important diseases of trees that have become widespread in the United States since the founding of the Arnold Arboretum a century ago.

Chestnut Blight

The rapid disappearance of one of our best forest, ornamental, and nut trees, the American chestnut (*Castanea dentata*), as a result of infection by the fungus *Endothia parasitica* is too well known to warrant much discussion today. Despite tireless effort and tremendous monetary expenditures, dead and diseased chestnut trees are all that remain of the losing battle man has waged to check this invader.

No one will dispute the statement that the chestnut blight disease has done more than any other single factor in American history to make the public tree-conscious. Within a span of 60 years many persons have witnessed the passing of this irreplaceable tree. Believed to be of minor importance when first reported by the late Herman Merkel, who found a few infected trees in Bronx Park, New York City, in 1904, the disease proceeded to wipe out the chestnut stands in New England forests and along the eastern slope of the Allegheny and Blue Ridge mountains, the principal range of this host. Today some chestnuts still stand in the extreme southern and western parts of this tree's natural range: in Tennessee, Georgia, and South Carolina. It is safe to say, however, that they too will soon suffer the same fate as their northern kin, for blight has been reported in all these states.

Dutch Elm Disease

The second most widely publicized disease in the last 35 years is the Dutch elm disease caused by the fungus *Ceratocystis ulmi*. The misleading name given the disease merely refers to the Netherlands, where it was first identified in 1919. The disease is believed to have entered the United States in the late 1920's on burled elm logs from Europe. After killing literally thousands of elms in the eastern United States, it has spread to the deep South, the Middle West, and Canada. The disease has been found in at least 33 states, the westernmost being Idaho.

Conditions are ripe, however, for the spread of the disease to California. The principal carrier of the causal fungus, the smaller European elm bark beetle *Scolytus multistriatus*, has been found in 20 California counties.

Many claims of cures or preventives have been made in recent years. However, as of now not one has been substantiated. I have worked with this disease since 1933 when I was in charge of the eradication campaign on Long Island. I have used many of the materials suggested as cures or preventives but found them all wanting.

Among a number of elm species introduced from Asia, the most resistant (though not immune) are the Siberian elm (*Ulmus pumila*) and the Chinese elm (*U. parvifolia*). Unfortunately they lack the qualities that have made the American elm so great a favorite over the past century, particularly in the New England states.

One of the latest efforts to control the disease on American elm seedlings has been exposure to thermal neutrons or x-rays. Four of 150,000 treated trees showed increased resistance, and one has withstood nine inoculations of the fungus *Ceratocystis ulmi*.

A sex attractant produced by virgin female elm bark beetles is also being investigated. If this substance can be produced synthetically in the laboratory, it may help to lure male bark beetles into traps where they can be killed or sterilized by any one of several methods.

A new approach is to use predators to control the insect vector. A wasp-like insect (*Dendrosoter protuberans*), introduced from Europe, lays its eggs in dead or dying elms infested with the larvae of bark beetles. The young hatching from the predator's eggs attack and kill the bark beetle larvae. Whether or not this predator can become sufficiently well-established to cause an appreciable reduction in the bark beetle population remains to be seen.

The use of systemic chemicals which are either injected into elm trunks or applied to the soil in the root feeding zone has been tried by several investigators. It was hoped that such chemicals would move up into the branches and twigs in sufficient amounts to kill the bark beetles which spread the causal fungus.

Encouraging results have recently been reported from the use of Benlate. In fact, only a few months ago, the du Pont Company, manufacturers of this fungicide, received clearance from the federal regulatory agencies to permit its use as an aid in the control of Dutch elm disease.

Benlate is applied as a foliar spray or is injected into the trunk of the tree.

As a foliar spray, it is used at the rate of 8 pounds in 100 gallons of water in spring when the leaves are fully formed. This is the time the bark beetles begin to feed.

As a trunk injection, it is used at the rate of 2 pounds per 100 gallons of water. Injector tubes equipped with cups of approximately 2 fluid ounce capacity are inserted into the outer growth rings just deep enough to prevent leaking at the point

of entry. The injector tubes are spaced at 2-inch intervals around the trunk. The cups are filled and left in place for 24 to 48 hours. They are refilled as needed. The injector tubes are removed when the treatment is completed.

The Benlate treatment must be given by a trained arborist.

It is to be hoped that this treatment combined with a sanitation and insect control program will be successful in slowing down this highly destructive disease.

Phloem Necrosis

Even more deadly than the fungus-induced Dutch elm disease is phloem necrosis. This disease was once thought to be caused by a virus but it is now known to be caused by a mycoplasma. Thousands of elms in the Middle West along the Ohio River basin have died from its effects in the past 30 years.

Just recently phloem necrosis has appeared in the western and central parts of New York State. It is only a matter of time before it will reach New England to destroy those elms that have thus far escaped the Dutch elm disease.

The phloem necrosis organism can be transmitted experimentally by grafting patches of diseased bark, scions or roots on healthy trees. In nature the infectious principal is transmitted by the elm leafhopper *Scaphoideus luteolus*. Because of the nature of the causal organism, there is a possibility that control of infected trees can be achieved by using an antibiotic such as tetracycline.

Oak Wilt

Another highly publicized disease, wilt, of oaks, is causing some concern to arborists, nurserymen, tree owners, and lumber interests in the Middle West. The disease has been found in 20 states from Kansas and Nebraska eastward to Pennsylvania, and from Minnesota southward to Texas.

The fungus *Ceratocystis fagacearum* is known to cause wilt. It is spread by root grafts and by several insects including fruit flies; Nitidulid beetles; the flat-headed borer, *Chrysobothris femorata*; and two species of oak bark beetles, *Pseudopityophthorus minutissimus* and *P. pruinosus*. The fungus can also be transmitted on tools used by arborists and foresters.

No effective control of wilt is known. For the present, eradication and burning of infected specimens is being advocated. Because the oak wilt fungus appears to be most infectious early in the growing season when the new spring wood vessels are developing, it is suggested that pruning operations in oaks be delayed until July or later.

Ash Dieback

In the northeastern United States, white ash (*Fraxinus americana*) has been affected by a branch dieback, and since 1940 occasional death of some of the affected trees has been noted. Dr. Craig Hibben at the Kitchawan Research Laboratory of the Brooklyn Botanic Garden found that a strain of tobacco ringspot virus was associated with leaves exhibiting early symptoms of ash dieback.

In addition, Dr. Hibben was successful in transmitting a mycoplasma-like organism from declining white ash trees showing witches' broom symptoms to healthy ash trees by means of the parasitic flowering plant known as dodder (*Cuscuta* sp.).

Although much research still must be done, these discoveries should eventually help to solve some very serious problems on white ash.

(The wood of white ash, by the way, is used to make baseball bats for America's favorite sport.)

Other important contributions on plant diseases have been made by arboreta and botanical gardens over the years. A brief review of some of these may be in order here.

At the Arnold Arboretum, more than 40 years ago, a forest pathologist, Dr. J. Horace Faull, was first to recognize the occurrence of the Dutch elm disease in the United States and warned of the potential danger of this disease to elms. Unfortunately his many warnings went unheeded. More widely recognized was the herbarium of specimens of diseases of native and cultivated plants prepared by Dr. Faull, his co-workers, and students.

Alfred Fordham, plant propagator at the Arboretum, found that many woody plants which failed to grow in spring died not from so-called winterkill but from the first sharp freeze in autumn. The bark of susceptible plants is ruptured and separates from the wood, resulting in death of the plant.

Donald Wyman, Horticulturist, Emeritus, at the Arnold Arboretum, found that some trees are unusually susceptible to certain pests and diseases and suggested that they should not be planted in areas where they cannot receive adequate care. He recommends, instead, the planting of trees that are unusually pest-free. Included in this group are: *Carpinus* species, *Cercidiphyllum japonicum, Eucommia ulmoides, Franklinia alatamaha, Ginkgo biloba, Gymnocladus dioicus, Koelreuteria paniculata, Liquidambar styraciflua, Phellodendron* species, and *Sophora japonica.*

At the Brooklyn Botanic Garden, classical research on virus

diseases has been conducted since the early 1940's, starting with Dr. L. M. Black and continuing with Doctors Karl Maramorosch, Myron K. Brakke and Walter Tulecke. Brakke's work on density gradient centrifugation was responsible for a new approach to the separation and identification of viruses. The contributions made more recently by Dr. Craig Hibben have already been noted in my discussion of ash dieback.

At the Cornell University Arboretum, now known as The Cornell Plantations, hundreds of elms are being grown to determine their resistance to the Dutch elm disease fungus.

At the Missouri Botanical Garden, early in this century Dr. B. M. Duggar contributed to the understanding of the future of viruses by measuring the tobacco mosaic particle. The garden also pioneered in the growing of mushrooms from pure culture spawn, transforming mushroom production into a profitable industry. In the 1930's A. P. Beilman made many contributions to the care of shade trees.

At the National Arboretum in Washington, D.C., Frank S. Santamour, Jr., research geneticist, has discovered the first natural hybrid between the tetraploid American elm and the highly resistant diploid Siberian elm.[1] More recently, another triploid elm, a hybrid of *U. pumila* and *U. rubra*, was found through cytological research.[2] According to Dr. Santamour, "It is likely that triploids created by crossing diploids with colchicine-induced tetraploids will be partially fertile and be useful in further breeding for resistance to Dutch elm disease".

There is one discouraging aspect in the development of plants resistant to fungi and other parasites. It is now well established that a plant resistant to one strain of a fungus may succumb to another strain of the same fungus. This has been shown in the development of varieties of wheat resistant to the rust fungus *Puccinia graminis*. The same situation holds for the fungus *Ceratocystis ulmi*, the cause of the Dutch elm disease. There are strains, particularly one known as the black line strain because it produces a black growth at its perimeter of growth in culture, that are extremely virulent and capable of killing an elm within a year of infection. Other strains are less virulent and may take three or more years to cause death.

Important contributions have also been made by the New York Botanical Garden. Pioneer work on the cytology and genet-

[1] Santamour, Frank S., Jr. 1970. A natural hybrid between American and Siberian elms. Forest Sci. 16: 149–153.

[2] Santamour, Frank S., Jr. 1971. A triploid elm (*Ulmus pumila* × *U. rubra*) and its aneuploid progeny. Bull. Torrey Bot. Club 98: 310–314.

ics of the fungus *Neurospora sitophila* was done by my predecessor, Dr. B. O. Dodge. This was followed by the work of other geneticists that resulted in the discovery of the chemical affinities of chromosomes and genes. For their part in these researches Doctors G. W. Beadle, J. Lederberg, and E. L. Tatum received the Nobel prize in medicine in 1958.

Other contributions made by the New York Botanical Garden, directly or indirectly related to plant ailments, include the effect of natural gas on trees, and the application of plant nutrients directly to the foliage of trees and shrubs.

The newly established 1800-acre Cary Arboretum of the New York Botanical Garden at Millbrook, N.Y., has among its objectives the finding of a replacement of the fast disappearing American elm, the mass planting of all elm species to assess their relative resistance to the Dutch elm disease, and the testing of blight-resistant clones of the American chestnut.

Thus down through the years, the study of plant ailments and their control continues to progress. Modern research at botanical gardens and arboreta such as the Arnold Arboretum is a far cry from the efforts of the ancient Romans to appease the rust gods with prayers and sacrifice.

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Cambial Activity in Trees

The major difference between trees on the one hand and herbs on the other is that the trees show lateral growth or growth in thickness, over and beyond the growth in length. The growth in length — called the extension growth — is due to division and elongation of cells at the tip of stem or root (Fig. 1). In trees, the subterminal regions which have ceased elongation undergo another kind of growth, the lateral growth which is due to cambium and which results in an increase in their girth. This is shown easily by a comparison of photographs of the same branch taken at different times (Fig. 2). In the photograph on the left the lowermost internode is about 1 1/2″ long, and the one above it is about 2 1/2″ long. After 3 weeks of growth (photograph on the right), a few more internodes have been added at the tip, but note that the bottom internode has not elongated. The one above it is now almost 3 1/2″ long and also has stopped elongating, soon the one above it will stop elongating, then the one still above and so on. If cross sections of these internodes are stained with phloroglucinol-HCl which imparts a red color to wood (Fig. 3), it can be seen that the cambial activity has begun in the two internodes from the bottom. Henceforth, these internodes will only increase in girth.

The cambium is a layer of cells between wood (xylem) and bark (phloem) [1] which remains permanently meristematic or capable of division. In temperate climates, the cambial cells are active only in spring and summer, they cut a number of new cells toward the wood, about 1/2 to 1/4 that number toward the bark, and the new cells differentiate, respectively, as new wood and bark cells. With the beginning of autumn, the cam-

[1] Strictly speaking the term *wood* pertains to secondary xylem or xylem derived from the cambium as opposed to primary xylem which is derived from the procambium. The term *bark* refers to all tissues outside the cambium and includes besides primary and secondary phloem such tissues as cortex, epidermis, periderm and rhytidome. In older stems of most trees the primary phloem, cortex and epidermis are shed and the bark consists essentially of the secondary phloem, periderm and rhytidome.

GROWTH AT TIP OF STEM (OR ROOT)	EXTENSION GROWTH	APICAL MERISTEM
GROWTH BELOW TIP	LATERAL GROWTH	CAMBIUM

Fig. 1 Two types of growth in trees, their location and meristems involved.

Fig. 2 Photographs of the same elderberry branch separated by a 3-week interval.

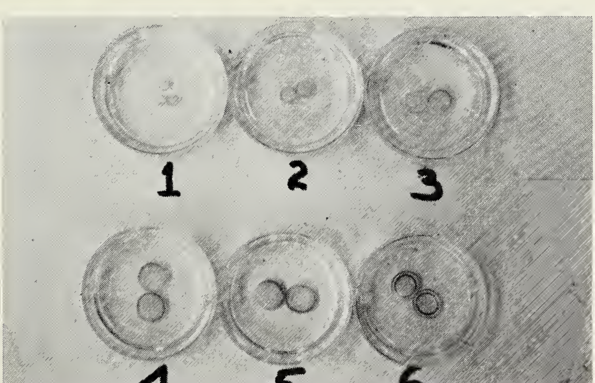


Fig. 3 Cross sections of six internodes from the youngest (1) downwards stained with phloroglucinol/HCl to show beginning of formation of wood (internodes 6 and 5) and hence beginning of cambial activity.

bial cells become dormant, remain in that state through the winter, and are activated again next spring. As a result of this seasonal activity of the cambium, there are growth rings in the wood, which may be considered as a record of cambial activity (Fig. 4). In contrast to the wood, the record of cambial activity is only poorly preserved in the bark (Fig. 4). First, the yearly increments in the bark are usually not distinct as growth rings. Second, they are further obliterated because of stress and distortion in mature bark due to the ever increasing diameter of the wood cylinder. Third, in most trees, the bark does not keep on accumulating from year to year as wood does; instead, the outer parts of bark are periodically cut off as bark scales by another kind of cambium, the cork cambium (Fig. 4). The formation and shedding of bark scales gives the trees their typical rough bark appearance. Some trees such as oak acquire a rough bark very early, at times within the first year; others like fir, poplar, birch, beech, and cherry may retain their smooth bark for several decades.

Wood is an important commercial product and a good deal of research has gone into it. Much less is known about bark, mainly from pharmacological work concerned with extractives; but cambium which produces both wood and bark, very little indeed is known about it. Yet the cambium is a very interesting tissue indeed. Since it produces xylem and phloem, two very different tissues, on its two sides [2] and since each of these two tissues is composed of different types of cells, it is of interest to students of oriented cell divisions, cell differentiation, and pattern formation in plants. Its seasonal activity in temperate climates, likewise, is of extreme interest to students of dormancy and frost resistance. Finally, a feature of cambium that has not been well recognized in the past is that it is a very dynamic tissue — it is the seat of rapid change and response to external and internal environment. In the following pages, I am going to concentrate mainly on cell types in the cambium, concept of the initiating ring, multiplicative divisions in the cambial initials and their role in plasticity of the cambium, and the effect of hormones on cambial activity and production of xylem and phloem.

[2] Some plants such as arborescent monocotyledons, tropical dicotyledons, and lianas show unusual cambial activity in that xylem and phloem are produced on the same side, at times in successive rings, or in different proportions in different radial sectors. Very little is known about the physiological and morphogenetical aspects of these types of cambial activity. They are not considered here.

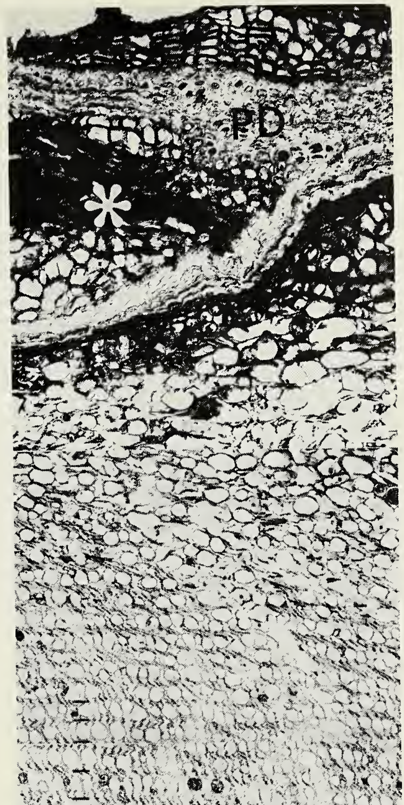
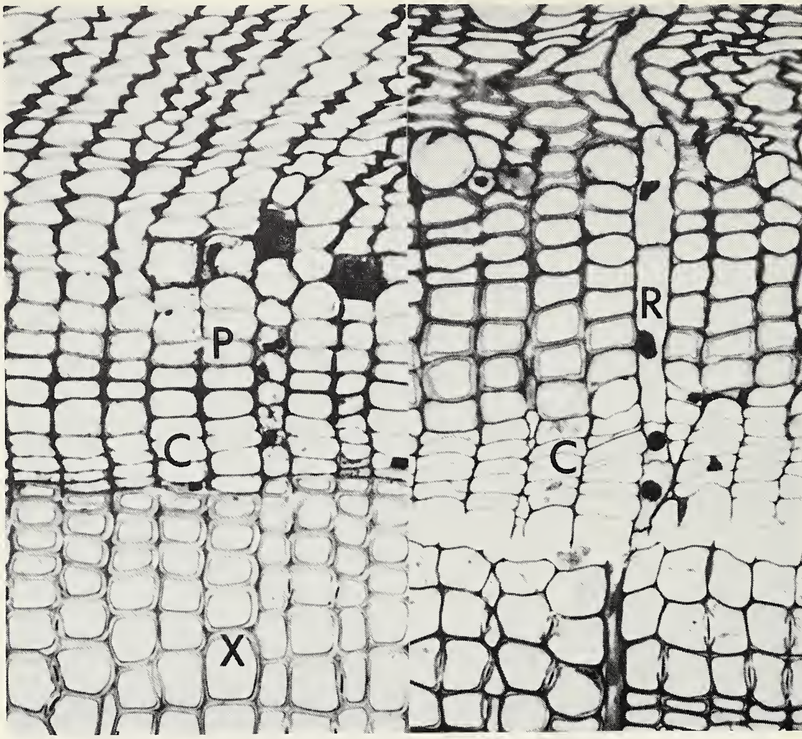


Fig. 4 Montage of a cross section of a stem of pine. Only two growth rings and part of a third are shown in xylem (X). In contrast several years growth, marked by small bars arranged in a row, is shown in the phloem (P). The approximate position of cambium is denoted by a longer horizontal bar. Note the distortion of tissue in outer bark and separation of outermost bark tissue by periderm (PD). The parts so separated comprise dead bark marked by an asterisk (*) and are periodically shed as bark scales.



Figs. 5, 6 Cross sections of stems of pine collected in winter and summer, respectively. Note that the zone of undifferentiated cell layers between the mature xylem (X) and phloem (P) is wider in summer than in winter. There is reason to believe that only one cell in a radial row acts as a cambial initial at any time. These initials maintain a certain degree of synchrony in their activity and occur more or less in a tangential line around the stem (C). The young differentiating xylem cells have weak walls and have ruptured during preparation of the material. Slippage of bark in spring and summer is due to this rupture and is indicative of cambial activity.

1. *Cambial layer, fusiform and ray initials*: There are theoretical reasons for maintaining that cambium is a single layer of cells (2, 3, 6) between xylem and phloem although it is not easy and often impossible to identify the cambial layer from the neighboring layers. Figures 5 and 6 represent cross sections of stems of white pine (*Pinus strobus*) sampled in winter and summer, respectively. In the winter collection 3–4 layers of undifferentiated cells intervene between the fully differentiated xylem and phloem cells. In the summer collection, the number

of layers of undifferentiated cells is much larger. Many of these, of course, are differentiating though not yet mature, xylem and phloem cells. With experience and under the higher resolution of an electron microscope it is possible to delimit the cambium both in winter and summer material to either one of 2 or 3 layers of cells. Further delimitation has proven impossible so far and perhaps is of little practical consequence.

The number of undifferentiated cell layers in winter and summer materials of different trees varies widely and in the same tree under different conditions of age, growth, and environment. For instance, in rapidly growing trees the number of undifferentiated and differentiating cell layers is usually much larger than in slow growing trees. Also, in winter collections of some trees, it may be possible to delimit the cambium to a single layer of cells.

These variations aside, the cambium basically has two types of cells (Fig. 7): 1. one type is narrow and elongated along the length of the stem and is called the *fusiform initial*; 2. the other type is short, isodiametric or horizontally elongated and clustered in groups and is called a *ray initial*. The type of cambium shown in Fig. 7 is common in most hardwoods such as birch, poplar, willow, alder, sycamore, etc. and is called *non-storied* cambium. The cambium of conifers is similar (Fig. 8), except that the fusiform initials are as a rule longer — in fact in some red woods they may be as much as 10 mm. long — and that the ray initials are usually arranged in single series. The cambia of some other hardwoods, such as ash and black locust (Fig. 9) have very short fusiform initials, as little as 0.3–0.5 mm. long, and have rather large clusters of ray initials. Irrespective of these differences between species, it is clear that basically the cambium has only two types of cells,[3] the fusiform and ray initials, and these two types of cells by tangential divisions produce all the different kinds of cells in wood and bark. But whereas the conducting cells such as the *vessel elements* in wood which transport water and minerals from roots up the trunk to the leaves, and *sieve elements* in the bark which transport the photosynthetic products from leaves down the trunk are produced only by the fusiform initials, parenchyma cells are produced by both. *Fibres* which provide strength to wood and bark are also produced exclusively by the fusiform initials. Besides differing in shape and size and nature of cells

[3] The only exception known is that of *Alseuosmia macrophylla* and *A. pusilla* which have been shown to have only fusiform initials in the cambia of their stems (5).

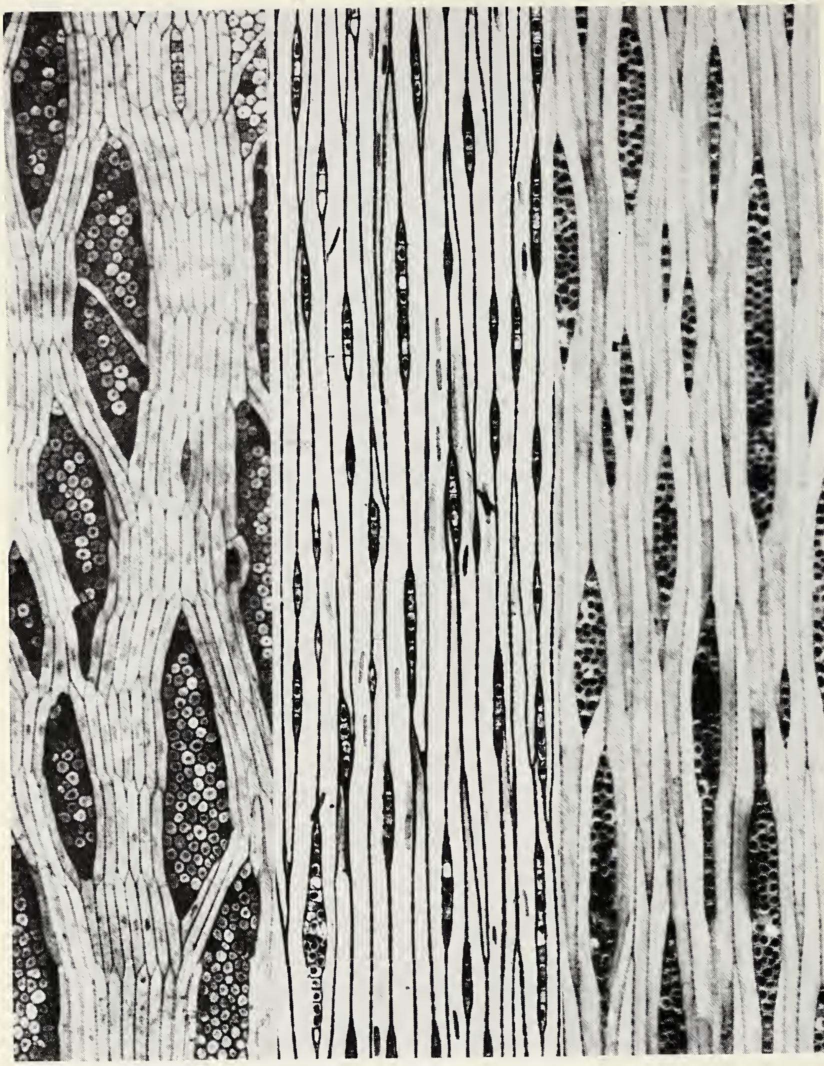


Fig. 7 left Tangential longitudinal section of the cambium of birch. Note that the fusiform initials are narrow and elongated whereas the ray initials are short and clustered in groups. The derivatives of ray initials on either side extend as sheets of cells called phloem and xylem rays (Fig. 6, R).

Fig. 8 middle Tangential section of the cambium of pine.

Fig. 9 right Tangential section of the cambium of black locust.

they produce, the fusiform and ray initials also differ in frequency of tangential divisions — the fusiform initials dividing far many more times than the ray initials in any one season.

What makes these two cells behave differently? As yet we have no explanation. There are vague suggestions of differential pressure and subtle differences at the molecular level but nothing concrete. Under the electron microscope the two types of cells show a basic similarity of structure which explains how the two may be interconverted one into the other but leaves the question — why the two behave differently — abegging.

2. *The concept of initiating ring*: The second noteworthy feature is that the production of new cells internally to the cambial ring entails a continuous net movement outward for the cambial initials and the bark tissues, and, furthermore, that the cambial initials show a remarkable degree of synchrony in their activity.

Figure 10 is a mock-up of the tangential activity of a single fusiform initial over part of a growth season. The mature (or previous years') xylem and phloem are distinguished from the current year's growth and the cambial initial is distinguished from its derivatives. The initial divides and the *internal* of the two cells — cell 1 — differentiates as a xylem element; it expands and pushes the cambial initial and mature phloem cells outwards. The cambial initial divides again, produces xylem derivative 2; derivatives 1 and 2 expand further and the cambial initial and mature phloem cells are pushed still further outwards. The cambial initial divides again but this time the *outer* of the two cells differentiates as the phloem derivative 1. The cambial initial divides again to produce xylem derivatives 3, 4, phloem derivative 2, and so on. This is, of course, a highly simplified model and does not assume tangential divisions in the young xylem and phloem derivatives. These divisions probably occur at a high rate in a growth season.

It should be remembered further that it is not simply one cambial initial that is engaged in this tangential activity. There are thousands of cells in the cambial ring — like soldiers marching in a row they are acting in concert, cutting cells toward xylem and less frequently toward phloem and as a net result moving outwards.

When soldiers march in a row and it is a hot day once in a while one of them pitches forward or backward and his neighbors move in from the sides and close rank. The same thing happens in a row of cambial cells — one of them drops out, or

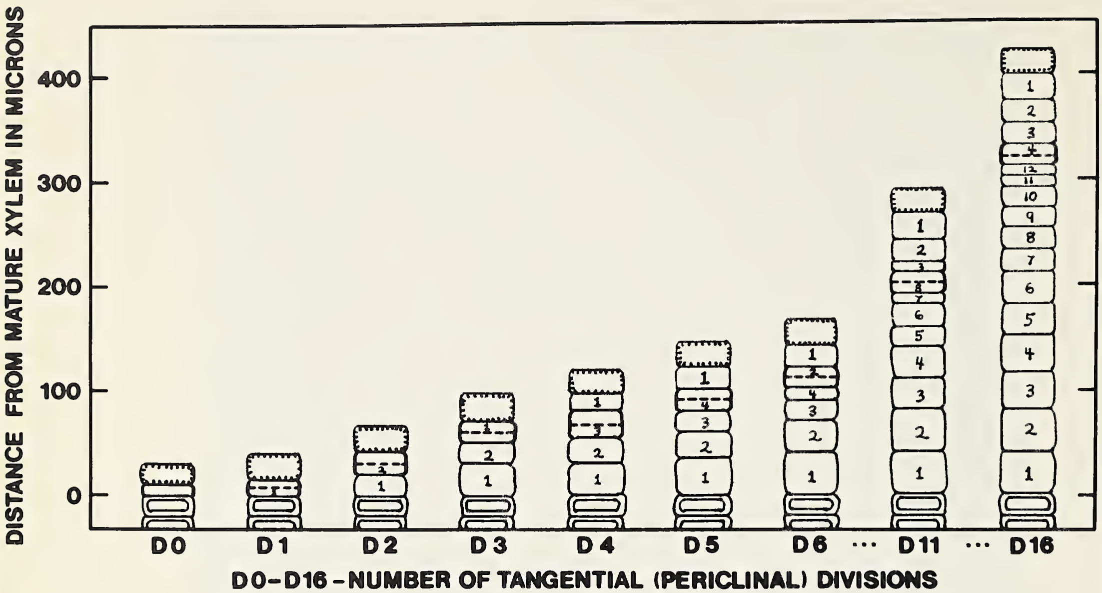


Fig. 10 An entirely hypothetical drawing showing the activity of a single cambial initial over part of a growth season. The mature or previous year's xylem and phloem are indicated by a double line and marginal stippling, respectively. The cambial initial is the cell with the broken line. Numbers indicate the order in which new xylem and phloem cells have been produced. The model does not assume tangential divisions in young xylem and phloem elements.

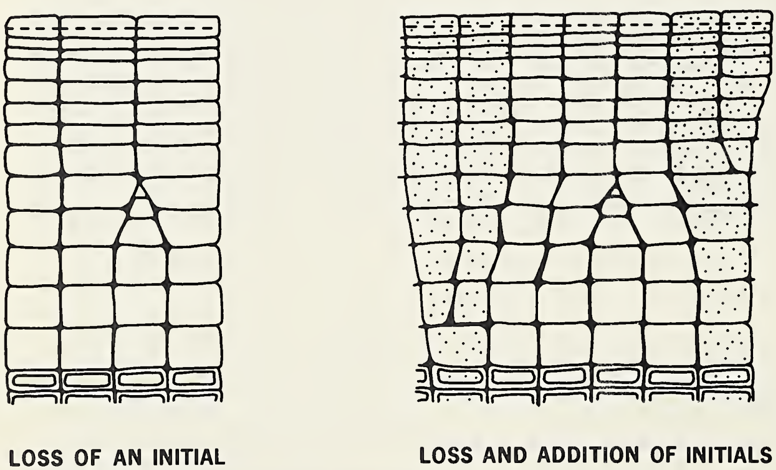


Fig. 11 Loss and addition of cambial initials as seen in cross sections of xylem including the cambial initials, but excluding phloem. Markings are the same as in Fig. 10. The figure on the left dramatizes the loss of an initial by expansion of cells in neighboring rows. The figure on the right is more nearly correct and shows that the loss of an initial may be compensated for by addition of new initials elsewhere in the ring (stippled rows).

more accurately stops dividing and the neighbors close in. It is a competitive world for the cambial initials; they have to keep dividing or else either pitch forward and mature into a phloem derivative or get left behind and mature into a xylem derivative. In Figure 11, for instance, one of the initials has stopped dividing and the neighbors are shown expanded to fill the vacated space (figure on the left). Actually, this kind of expansion does not take place; instead as shown in the figure on the right, new cambial initials are added to the cambial ring. This dropping out or loss, or as we prefer to call it decline, can be sudden or protracted, but it is obvious that for each initial that declines at least one initial must be added if the cambial ring is to maintain its diameter; more than one if it is to increase in diameter. This leads us into the second type of division — the multiplicative (or anticlinal) division — that the cambial initials undergo.

3. *Multiplicative divisions*: Let us assume that a tree 20 cm. in diameter, after 50 years of growth, becomes 200 cm. in diameter, and further that the size of the cambial initials (tangential width) remains constant at 20 μ. Let us further restrict ourselves to fusiform initials. As Figure 12 shows, it can be calculated that the young tree has 10,000 initials in the cambial ring, and this number must be increased to 100,000 when the tree is 200 cm. in diameter, an increase which can be obtained if each initial multiplies a minimum of 9 times over the 50 year period. Actually the initials do increase in size (Table 1) and so the number of necessary multiplicative divisions would be less than 9. Surprisingly, however, in nearly all plants that have been investigated this number is much

Table 1. Actual measurements from *Pinus strobus*. Adapted from Bailey (1).

	one year old stem	60 year old stem
Radius of woody cylinder	2,000 μ	200,000 μ
Circumference of cambium	12,566 μ	1,256,640 μ
Average length of fusiform initials	870 μ	4,000 μ
Average tangential diameter of fusiform initials	16 μ	42 μ
Average tangential diameter of ray initials	14 μ	17 μ

CIRCUMFERENCE = $2\pi r$
TANGENTIAL WIDTH OF AN INITIAL = $20\,\mu$
CIRCUMFERENCE OF A TREE 20cm IN DIAMETER = $\pi . 2 \times 10 \times 10 \times 1000\,\mu$
NUMBER OF INITIALS = $\dfrac{\pi . 2 \times 10 \times 10 \times 1000}{20} = 10{,}000$

AFTER 50 YRS.

CIRCUMFERENCE OF A TREE 200cm IN DIAMETER = $\pi . 2 \times 100 \times 10 \times 1000\,\mu$
NUMBER OF INITIALS = $\dfrac{\pi . 2 \times 100 \times 10 \times 1000}{20} = 100{,}000$

$\therefore$ 1 INITIAL MUST GIVE RISE TO 10 INITIALS
OR MULTIPLY A MINIMUM OF 9 TIMES IN 50 YEARS

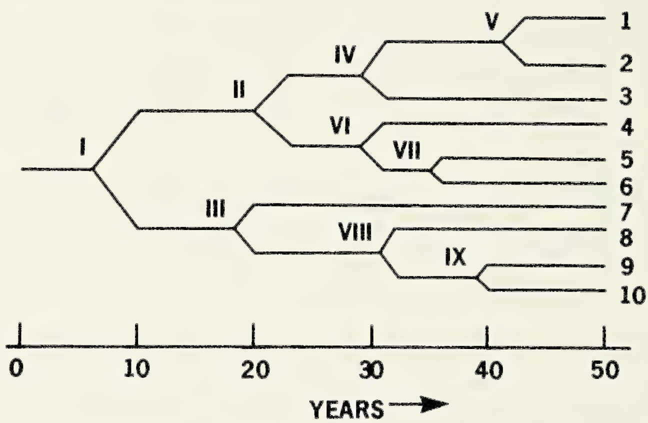


Fig. 12 The expected increase in number of fusiform initials over a 50-year growth period can be shown in the above manner. Roman numerals preceding bifurcations denote multiplicative divisions. For details see text.

greater than 9, at least 2 to 3 times as much (Fig. 13). The excess cells that are produced either decline completely or bits of them are left in the initial ring by conversion to ray initials.

Why should there be such an excessive production of new initials followed by a rejection of a large number of them? The answer to this question is unknown though it seems reasonable to assume that this device enables the cambium to adjust itself to changing conditions of growth and environment. It produces far more cells than it needs and hence can pick those that are wanted and throw out those that are not wanted.

Let me explain this by a few examples:

a. *Eccentric wood*: Trees normally grow straight but at times due to wind or snow or competition from neighboring trees they

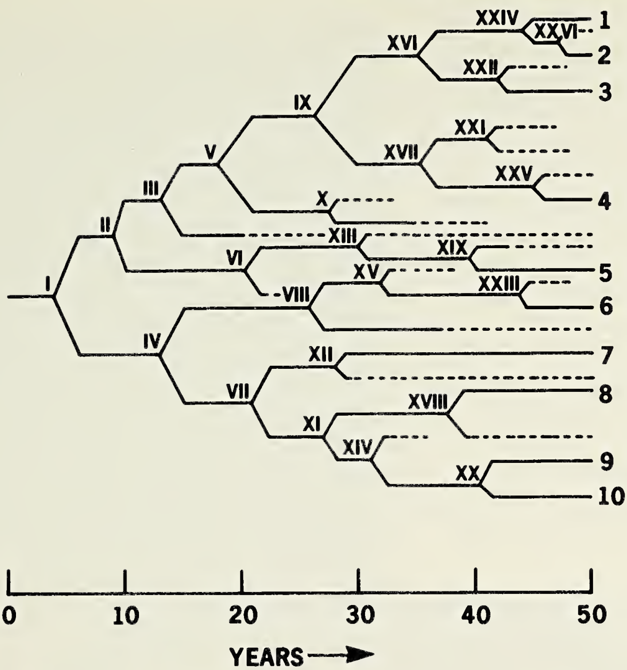


Fig. 13 This figure is similar to Figure 12, but shows that the number of multiplicative divisions is much higher than 9 and that the excess initials are lost by decline (lines which terminate somewhere and do not reach the right end) or are converted to ray initials (broken lines).

bend in a certain direction. If the tree is sawed, one sees growth rings in the wood that are eccentric rather than concentric (Fig. 14). This figure is further unusual in that it shows that the plane of eccentricity may change with time. In this stem there are at least 3 such planes which are marked by arrows. It should be noted that in the sectors marked by arrows, the cambial initials were not only producing more wood per year, but also there was a larger number of cambial initials than in the sectors on the opposite side.

b. *Repair mechanism*: Another instance of where it is useful to have more cells than are needed is in repair of an injury. If some cells in the cambium and adjacent xylem and phloem are injured, the cambial cells on either side of the injury divide up into smaller cells, each of which behaves as an independent unit; these new initials then elongate, multiply, reject the un-

wanted pieces, elongate, multiply, further reject the unwanted pieces, and eventually give rise to straight elongated initials in a complete cambial ring.

c. *Accommodation with parasitic plants*: Still another way in which the cambial cells show adaptability is in accommodation with parasitic plants, such as mistletoes (*Phoradendron, Arceuthobium*) and dodder (*Cuscuta*). Seeds of these plants germinate on a host branch and send out haustorial appendages which grow in the host cortex and send out aerial stems which flower and seed. Tips of some of these appendages also come to rest against the cambial initials which respond by dividing into a number of smaller cells; the latter surround the haustorial appendage and henceforth the cells in the haustorial appendage divide tangentially and keep pace with similar divisions in the cambial initials (7). Thus, at the end of several years, sections of haustorial appendages — now known as sinkers — appear buried deep in the host wood and draw water and nutrients from the host xylem (Fig. 15). But the advantage from the host's

Fig. 14 Section of a stem showing eccentric growth rings.

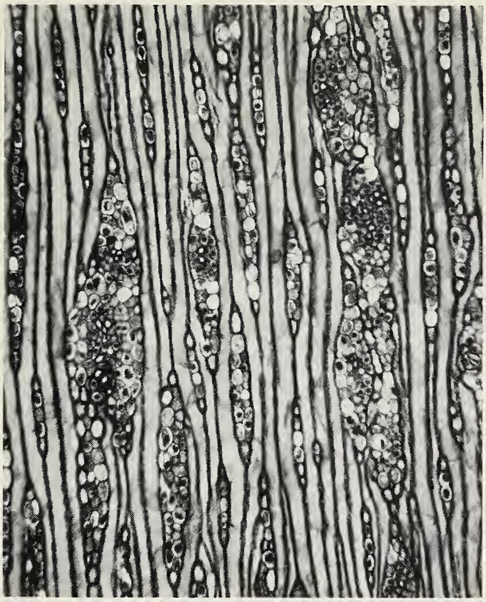


Fig. 15 Tangential section of wood of hemlock which is infected with dwarfmistletoe. The large xylem rays are occupied by parasitic sinkers. The narrow uniseriate rays represent the normal condition.

point of view is that an accommodation is made with the parasite and unless the infection is very severe the splitting of wood is avoided and the host is able to survive for a long time.

The multiplicative divisions therefore are necessary, not only to maintain the cambial ring and prevent it from bursting because of increasing diameter of the wood cylinder, but they also confer a degree of plasticity on the cambium, which would be absent otherwise. Cambium is hardly the placid tissue that monotonously keeps cutting xylem and phloem cells; it is the seat of active change, of constant multiplicative divisions, of frequent conversions between ray and fusiform initials, and of adjustment to changing conditions of growth and environment.

d. *Spiral vs. straight grain*: Another phenomenon controlled by multiplicative divisions is that of spiral vs. straight grain wood. In straight grain woods, the fibres are arranged axially in line with the longitudinal axis of the stem, but in spiral grain they are placed at an angle and seem to describe a clockwise or an anticlockwise spiral in relation to the longitudinal axis of the stem. How do the straight and spiral grains arise? They have their basis in the multiplicative divisions in the fusiform initials.

In conifers and most hardwoods such as birch, poplar, alder, willow, etc. these divisions are of the *pseudotransverse* type, such that the new cambial initials are nearly half the length of the original initial (Fig. 16). Subsequently the new initials grow at their tips until they reach the length common to the fusiform initials in that region. During this tip growth they, of course, continue to divide tangentially and produce new xylem and phloem cells. The plane of the new division determines the direction of the subsequent tip growth. Usually the divisions occur in the two planes in about equal frequency, so that on elongation the initials and the xylem and phloem derivatives maintain their more or less vertical orientation (Fig. 17). But at times the divisions occur only in one plane. This phenomenon, combined with subsequent tip growth, results in a skewering of the fusiform initials and their xylem and phloem derivatives, either in a clockwise or an anticlockwise direction. Spiral grain is mainly associated with wood but can be seen in bark if it has lots of fibres (Fig. 18). The environmental factors which cause the pseudotransverse divisions to occur in one plane are still unknown, but records show that the spiral can change direction and become straight.

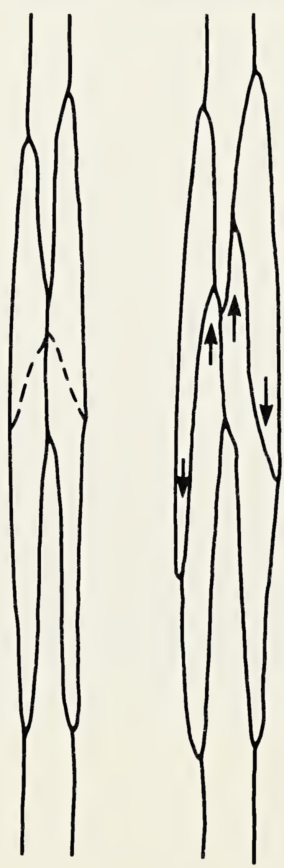


Fig. 16 Pseudotransverse divisions (shown by broken lines in the figure on left) and subsequent tip growth (direction shown by arrows in the figure on right) in fusiform initials of nonstoried cambia.

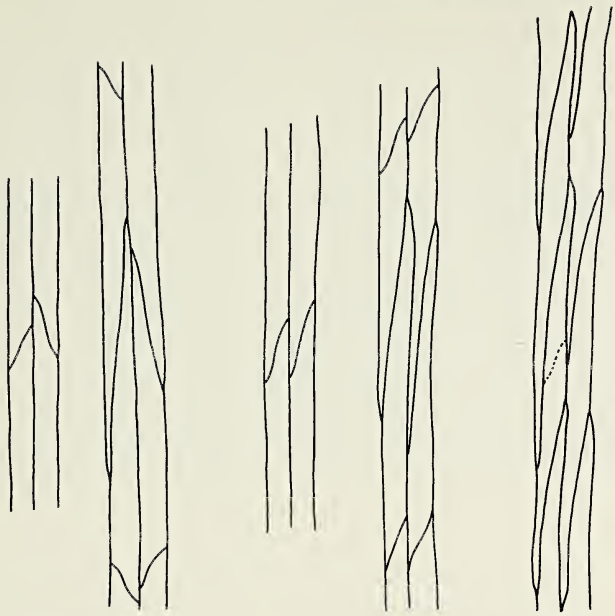


Fig. 17 Straight and spiral grain have their basis in the planes of pseudotransverse divisions and subsequent tip growth of new initials.

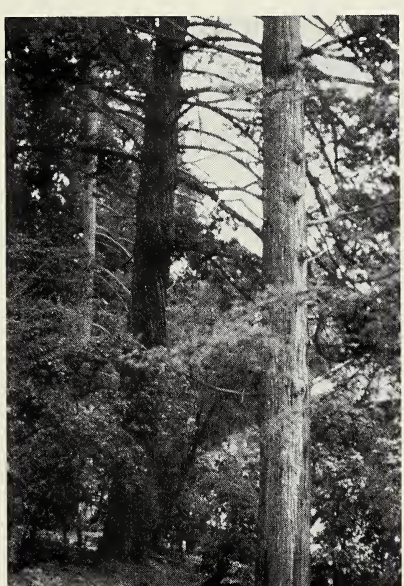


Fig. 18 Two trees of a conifer species growing side by side in Nara near Kyoto, Japan. One shows spiral grain, the other straight grain.

4. *Seasonal growth and xylem and phloem production*: I have mentioned earlier that in temperate climates the cambium becomes dormant in autumn and is reactivated in spring. The dormancy and reactivation of cambium are very little understood though there is reason to believe that daylength, temperature and relative concentrations of certain plant hormones play a role. With approaching autumn there is a shortening of daylight hours and a fall in temperature. If trees growing outside in the summer are transferred to growth chambers which simulate the daylength and temperature conditions of summer months, the cambium remains active and continues to produce new wood and bark cells. If these trees are then suddenly taken outside they get killed with the first frost. In contrast, the trees in the field become dormant with the onset of fall and then are able to survive very cold temperatures. In some experiments dormant twigs collected in winter were dropped in liquid nitrogen (−196° C) and on thawing their buds were still able to produce new branches. Just as cambial growth can be extended by appropriate control of daylength and temperature, one can also induce dormancy. In recent years a plant hormone appropriately called dormin (abscissic acid) has been extracted from buds and leaves of plants which were induced to become dormant, and, as expected, external applications of this hormone on growing trees have induced dormancy.

The reactivation of cambium in the spring has been related to another class of hormones, the auxins, specifically IAA. It has been suggested that in spring this hormone is present in increasing amounts in the buds and young leaves and then flows downwards, awakening the cambium so to say from its winter sleep by its magical touch (8). That IAA is involved in cambial activation is shown beautifully by a simple experiment. Twigs of poplar, birch, black locust or some other tree are collected in autumn and stored in a cold room (4° C) for a few months. After the cold treatment, which seems to be necessary, they are placed right side up in a small amount of water and their top ends are pasted with lanolin and with lanolin and various hormones individually and in combination. After 3 weeks, sections can be cut to see whether cambium is active and if so whether xylem is being produced, or phloem, or both, and in what proportion. From these experiments it appears that both auxin and gibberellic acid can induce cambial activity but whereas auxin promotes xylem formation, gibberellic acid seems to promote phloem formation (Fig. 19).

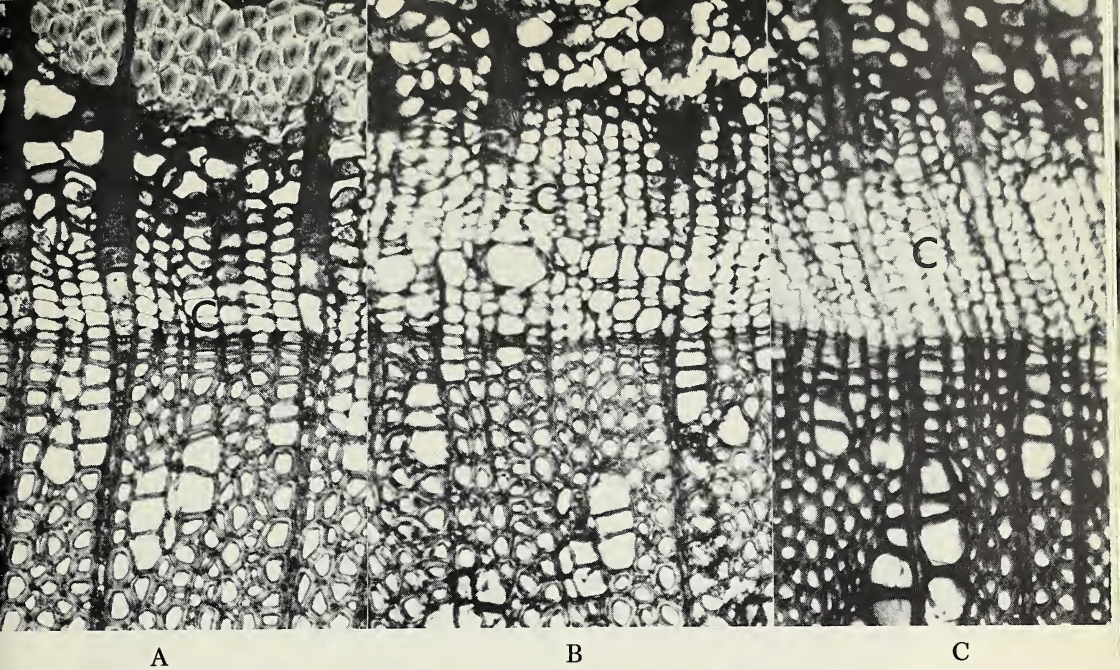


Fig. 19 Cross sections of stems of poplar. A. from twigs which received only lanolin treatment, B, from twigs which received lanolin and IAA at 100^{ppm}, and C. from twigs which received lanolin and GA at 100^{ppm}. Note that the cambium (approximate level marked by C) is more active in B, C than in A; note also the formation of new xylem elements in B and their lack in C. Photographs are mounted such that the mature (or previous year's xylem is at the same level (Photographs courtesy of Mrs. V. Lai).

The ultimate aim of all biology is to understand why a cell does what it does and how it does it. We want to know why fusiform and ray initials are different, why some cambial initials lose out while others persist in the ring, what triggers a cell to become a xylem or a phloem cell, and so on. Basic questions, perhaps of no economic value, but of fundamental importance to biology to which we still have no concrete answers. In an attempt to find answers to these questions, some investigators have tried to culture cambial cells. They have excised the cambial cells from the tree, and grown them in agar or liquid culture under well defined growth and nutritive conditions. But unfortunately, to date, all these attempts have failed for in culture they no longer behave as cambial cells — they lose their characteristic shape, become spherical, there are no oriented divisions and there is no oriented production of xylem and phloem (Fig. 20). There is a certain element of mob psychology involved here. Outside their own milieu or deprived of

their particular microenvironment in the tree which may include pressure, oxygen tension, and hormonal balance, these cells no longer behave as cambium. That pressure is involved is shown by some other experiments in which flaps of bark including cambium were lifted (see slippage of bark in Fig. 6), a sheet of polyethylene inserted between the flap and the stem, and measured amounts of pressure applied to the flap. The cells in the flap continued to live; the cambial cells continued to divide and produce oriented xylem and phloem derivatives (4).

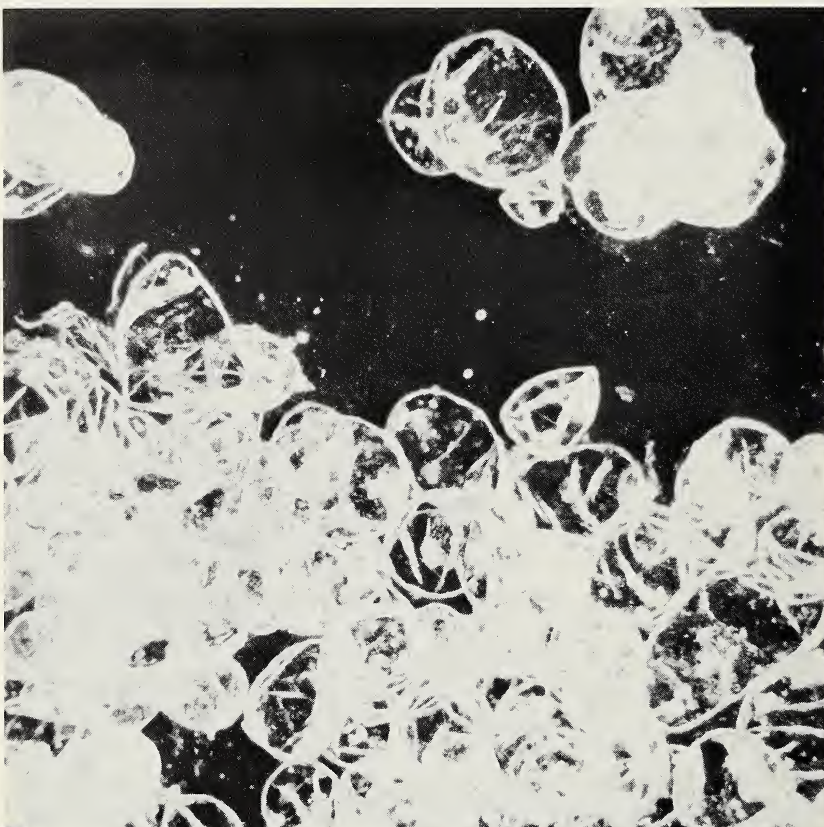


Fig. 20 Cambial cells in liquid culture. Explants from cambial region of Acer pseudoplatanus. *(Slide courtesy of Dr. P. Albersheim.)*

To recapitulate I have tried to show that the cambial ring moves outward with increasing diameter of the wood cylinder and that whether or not a cell behaves as a cambial initial depends to a large extent on how well it is able to maintain itself in the initiating ring. I have further tried to show that the cambial cells are in a state of constant flux and are the seat of changes which enable the tree to adjust itself to changing conditions of growth and environment. Finally, I have tried to show that the dormancy and activation of cambium as well as differentiation of the xylem and phloem are at least in part controlled by physical factors such as daylength, temperature, and pressure and relative concentrations of at least three different types of plant hormones — dormin, auxin, and gibberellin.

These bits of information on the structure and physiology of cambium whet rather than assuage the curiosity for a greater understanding of this remarkable tissue. Arboreta, being the repositories of trees, have an important role to play in directing and supporting research on cambium. On this one hundredth anniversary of the Arnold Arboretum, I am happy and proud to say that the Arnold Arboretum has fulfilled this role admirably and, hopefully, will continue to do so in the future.

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The Wood Collection—What Should Be Its Future?

A wood collection maintained for scientific purposes is much the same as an herbarium in that it contains a preserved portion of a plant with associated documentation filed in an organized manner. By and large, wood collections so defined, are maintained by institutions rather than by individuals. There are about 14 wood collections in the United States housed in almost as many institutions. In the entire world there are only 115 institutional collections of wood. Pre-eminent in terms of numbers of specimens is the collection housed at the U.S. Forest Products Laboratory in Madison, Wisconsin where there are about 100,000 woods.

Until a few years ago, there were six major collections of wood in the United States: the Samuel James Record Memorial Collection housed at the School of Forestry, Yale University; the Harry Philip Brown Memorial Wood Collection at the New York State College of Forestry, Syracuse; the collections at the Field Museum of Natural History, Chicago; the collections at the U.S. Forest Products Laboratory, Madison; the woods at the Smithsonian Institution, Washington; and the woods forming the collections at Harvard University. Today, only four of these collections survive at the founding institutions: the Brown Wood Collection at Syracuse, the Smithsonian collections, the wood collections at Harvard, and those at Madison. The Field and Yale collections have been consolidated with those at the U.S. Forest Products Laboratory.

The wood collections of the Field Museum in Chicago were among the first collections of any kind at the Museum and they formed the original material of the world-renowned economic botany collections. Following the dismantling of the displays which comprised the World Columbian Exposition at Chicago in 1893, much of that material was transferred to form the nucleus of the collections at the Field Columbian Museum which was established shortly after the great exposition. The first curator of botany was Dr. Charles F. Millspaugh, a West Vir-

ginian, who had served on the jury of awards of the World Columbian Exposition. He was responsible in large part for the collections resulting from the Exposition which were left to the newly founded museum. The first exhibit materials of the Department of Botany of the Museum consisted of exotic woods, in the form of boards, remaining from the Exposition. These were put on display in 1894 in what had been the Fine Arts Building of the World Columbian Exposition.

Millspaugh augmented the exotic woods derived from the Exposition with native woods from the United States, and some of the earliest collecting activities of the Department of Botany were dedicated toward this end. Millspaugh himself participated in these early expeditions and travelled to the southern states, Louisiana and Mississippi, for example — during the winter, of course. Later, additions to the collections were made through the efforts of Huron H. Smith, a loner, who collected wood specimens with herbarium vouchers from distant parts of the United States, particularly on the West Coast. It was these woods, in the form of boards and tree trunks, and herbarium specimens, which formed the basis for the displays in the Museum's Hall of North American Woods. After his tenure at the Field, Smith accepted a curatorship at the Milwaukee Public Museum.

Exotic woods were also gathered for the Museum, notable among which were the collections of Llewelyn Williams from Peru and Acosta-Solís from Ecuador. But, as originally, most of the wood specimens were used primarily as examples of economic products of plants and to serve as bases for displays of useful timbers.

Llewelyn Williams had travelled to Yale where he took courses in wood anatomy and identification under the tutelage of Professor Samuel J. Record. Subsequently he returned to the Field Museum where he undertook studies in wood anatomy until the beginning of World War II. Williams' work on the woods of northeastern Peru, published in 1936, resulted in part from these studies and from his field work in Peru. But, Williams' investigations were probably the only research in the comparative anatomy of wood based on the Field collections actually carried out at the Museum. Nevertheless, collections of wood continued to be amassed in the hopes that there would be a full-time curator of dendrology or a wood anatomist on the staff to organize and direct a viable program of research in wood structure which could be carried out *in situ*. Those who had charge of the collections over the years — Llewelyn Williams, B. E. Dahlgren, John W. Thieret, Theodore Just, Louis O. Wil-

liams, and research associate Archie Wilson — made the specimens available for study elsewhere by botanists and others with an interest in studying wood structure, while at the same time they continued a holding operation for the future of the Museum.

It finally became apparent that chances of establishing a program based on wood study at the Field Museum were remote. Reluctantly, after more than seven decades, the wood collection proper was turned over to the U.S. Forest Products Laboratory in 1971 where it was hoped more use could be made of the specimens than was possible in Chicago.

The exhibits of North American timbers are still being maintained in a revitalized and decorative format. This amazing series of cases, containing dioramas and displays on the botanical aspects and economic products of woody plants, constitute the most complete pictorialization of the raw material of our forest resources in any museum today.

The wood collection previously housed at the School of Forestry, Yale University, was begun almost coincident with the founding of the School itself and records show that a collection existed in New Haven in 1901. However, this group of specimens was burned in 1903 and the now famous Record Memorial Collection had its origin in 1905. Samuel James Record joined the faculty of the School in 1910 and in 1917 he was appointed Professor of Forest Products. His immense interest in woods sparked several trips to the tropics — Guatemala, Honduras, British Honduras — and to many portions of the United States for purposes of observing forest trees and for the collection of wood specimens. It was Record, primarily, who elevated wood collecting from its former status of guesswork and curio gathering to a truly scientific occupation. He insisted that samples of wood be accompanied by determinable herbarium specimens gathered from the same tree and thus associable with described species of plants. These voucher specimens were kept at the Forestry School, adjacent to the woods, where they could be consulted as the need arose.

By 1916 a committee of the Yale Corporation voted to recommend for favorable consideration the formation of a department of tropical forestry at the School with appropriate support in terms of finances, faculty, laboratory, museum furniture, and so forth. An important arm of the department was to be the museum and collection of tropical woods begun by Professor Record. In 1928, Record had already assembled the then incredible number of 11,000 specimens of wood, largely from

tropical regions. The size of the Yale collection in 1928 was larger than most institutional wood collections of the present time.

Record's success in obtaining wood specimens was not only brought about through his own activities in the field; he had an enormous correspondence and he must have been a very stimulating and persuasive man. He was able to secure financing from external organizations which he used to provide stipends for botanists and foresters in the field so that they could gather woods for him; he helped many United States and Latin American botanists with their endeavors in the tropics, for example, through modest subventions for the collection of wood specimens. It was Record who helped to support the field work of G. Proctor Cooper in Liberia, Panama, and Costa Rica; of Hugh Curran in Argentina, Brazil, and Venezuela; of Armando Dugand in Colombia; and of Adolpho Ducke in Brazil. By the time Record died in 1945, the collection amounted to over 40,000 specimens, far and away the largest and probably best collection of its kind in the world.

Record founded the journal *Tropical Woods* which was published more or less uninterruptedly from 1925 until 1960. He also wrote the two most important works on the woods and forests of the New World, *Timbers of Tropical America* in 1924 and *Timbers of the New World* in 1943. In addition, Record authored several books on the physical and mechanical properties of wood and on the description and identification of wood. His research output was voluminous, much of it being published in *Tropical Woods*.

Record established a unique form of exchange with Professor Laurence Chalk, then in charge of the wood collection at the old Imperial Forestry Institute, Oxford University. In return for specimens of wood, Chalk arranged to have permanent microscope slides prepared of them, which were returned to Record. These slides formed the basis of the large collection associated with the woods at Yale.

Service was also an important part of the work done in conjunction with the collections at New Haven. Many thousands of specimens were distributed as duplicates on exchange to other collections and as small samples for microtome sectioning and research. Record himself performed wood identifications for lay people as well as for the government and industry, for botanists, anthropologists, and foresters. The collections also formed a basis for studies in the utilization of tropical woods and as demonstration specimens in teaching.

Following Record's death in 1945, the curatorship was held for a few years by Record's protege, Robert W. Hess. But Hess left Yale to join industry in the early 1950's, and following an interim appointment of the then retired Arthur Koehler, I assumed the responsibilities of the curatorship; teaching and research in wood anatomy and identification, tropical forestry, and microtechnique; editing *Tropical Woods*; and of the service work which seemed to be received unabated even in 1953 owing to the vast reputation of Samuel Record.

The entire program of research in tropical woods and tropical forestry was made possible by the activities surrounding the great collection of woods. It was an integrated program embodying several facets of endeavor: research, teaching, publication, and service. But these activities had only been viable owing to interests and efforts of the curators of the wood collection and not to any great impetus or encouragement from the School or the University. Following my departure from the School of Forestry in 1960, the entire program so ably commenced and overseen with such vigor and excellence by Samuel Record, fell apart. The new wood anatomist had little interest in the tropics and even less in the "busy work" of curating woods and editing a scholarly publication. Thus, the collection became remote and difficult to consult, *Tropical Woods* discontinued publication permanently, and ultimately the administration of the Forestry School, seeing no hope for a future program, transferred the wood collection to the U.S. Forest Products Laboratory in 1969.

Wood collections at the New York State College of Forestry, Syracuse, came into being shortly after the arrival of Harry Philip Brown in 1917 or 1918. The exact date of accessioning of the earliest specimens is unknown. Brown used these woods in his teaching of wood identification and in his publication, *Atlas of the Commercial Woods of the United States*, which appeared in 1928. Many of these early woods were not authenticated, that is, they were not associated with herbarium vouchers. It was Brown himself who made the early collections and others contributed specimens as well: William M. Harlow, Ellwood S. Harrar, and S. B. Detweiler of the U.S. Forest Service. Later specimens were collected with herbarium vouchers which were not, however, housed at the College; rather, they were deposited at the U.S. National Herbarium, in the herbarium of the Arnold Arboretum, and in the herbarium of the New York Botanical Garden. Records of deposition were maintained at the College.

In the 1920's, at the request of the British Colonial Office, H. P. Brown visited India to organize a botanical section and laboratory for the study of wood at the Forest Research Institute and Colleges, Dehra Dun. There, Brown had the opportunity to work with and to become familiar with Indian timbers through the famous Gamble Collection. He remained in India for a year and a half and following his return to Syracuse, in 1932 he and R. S. Pearson, published the monumental two-volume work on Indian timbers, *Commercial Timbers of India.*

Besides the use of the Syracuse collections for teaching, considerable service and research in wood anatomy was also carried out: R. A. Cockrell worked on *Strychnos* and studied woods from Sumatra collected by B. A. Krukoff; E. S. Harrar studied the woods comprising the Queensland (Australia) Forest Service collections; Luis J. Reyes studied Philippine woods and in 1938 produced a volume on Philippine timbers; Kafil. A. Chowdhury worked on Indian woods; and A. J. Panshin's research in anatomy involved collections from West Africa. H. P. Brown attracted many students and there was a very active program in the study of wood structure.

At the present time, Professor Carl de Zeeuw is curator while at the same time he teaches courses in wood structure, identification, and utilization. There is still a modest program of incorporation of new specimens and some small amount of research in wood anatomy is carried out. A major effort, at this time, involves the continuing authentication and accessioning of wood specimens already on hand, since many woods were received in the past with but little documentation, despite collection by well-known botanists such as Joseph Rock.

A word must be inserted here about the program of collecting, known at the New York State College of Forestry as "Project I". This project, spearheaded by H. P. Brown, was an attempt to collect wood specimens, ecological and habit data, and herbarium vouchers, from all the woody plants growing within the continental United States. To this end, Brown enlisted the aid of collectors from all parts of the country and in return for duplicate specimens these persons were asked to gather appropriate material from the forest trees native to their parts of the country. Accordingly, botanists, foresters, range and wildlife managers, were "drafted" to help with this monumental undertaking. Although at first Brown only admitted woods of commercial or potential commercial use, he later relented and the more recent collections comprise material from all woody plants. The project is still being carried on to a modest degree

and to date there are over 850 collections. Duplicate sets of the wood specimens have been distributed far and wide and the herbarium vouchers and associated documentation are deposited in the herbaria mentioned above.

The wood collection presently housed at the U.S. Forest Products Laboratory at Madison was founded sometime prior to 1910 by Arthur Koehler, the notable "expert on wood" at the Lindbergh kidnapping trial in 1935.

Woods were then housed in Washington, D.C. before the construction of the present facilities in Madison. Initially, the collections were strictly of native forest trees. In those early days the specimens were used predominantly as comparative material for identification and only secondarily for research, description, and the construction of keys. Present emphasis at the Forest Products Laboratory is much the same as it was in 1910, that is, most of the activities are devoted toward the identification of wood specimens and the maintenance of the wood collections themselves. For example, there are on the average over 1000 inquiries during a typical year and these amount to some 4000 identifications.

Arthur Koehler worked closely at the Laboratory with Eloise Gerry, a classmate at Columbia University of the anatomist-morphologist-geneticist, Edmund Sinnott. When Koehler retired, his position was assumed by B. Francis Kukachka, who had been at the Laboratory since 1945, and who is now in charge of the program of service and research associated with the wood collections. The major emphasis at the U.S. Forest Products Laboratory has always been service to the public, largely in the form of identifications. To this end, the Laboratory amassed a collection of specimens of wood, many consisting of pie-shaped radial segments, which numbered about 23,000 specimens in 1967. With the addition in 1969 of Yale's Record Memorial Collection of 55,000 specimens and subsequent augmentation in 1971 of the Field specimens comprising 18,000 specimens, the wood collections at the Forest Products Laboratory now number about 100,000 specimens, easily the largest wood collection in the world.

With this great and rather precipitous increase, the wood collections, associated staff, and facilities at the Laboratory have been styled by the Director as a "Center for Wood Anatomy Research". It is hoped, with this vast increase in physical assets in terms of wood specimens, that there will be additional staff beyond the two permanent staff members now associated with the wood collection to enable an increase in activities, primarily

in the field of codifying information on wood structure for incorporation into a program of data processing. Work continues to integrate both the Yale Record collections and the Field collections into the already existing specimens at the Forest Products Laboratory. The herbarium of voucher specimens once housed at Yale is being intercalated among other vouchers already housed at the Forest Products Laboratory.

Wood collections at the Smithsonian Institution were originally part of the Division of Arts and Manufactures of the Museum of History and Technology, and it was not until 1960 that they were transferred to the Department of Botany in the Museum of Natural History at the urging of Albert C. Smith, then Director of Natural History. In 1915, when the first wood specimens were catalogued, they were associated with the industrial and manufacturing sections of the Museum. Subsequently, they were stored next to an exhibit hall devoted to the commercial aspects of wood. The first curator, William N. Watkins, had been graduated from the New York State College of Forestry and his primary outlook was that of a wood technologist and expert in wood utilization. Accordingly, he was occupied in the amassing of specimens primarily for use in identification and service to the public. Specimens were made available to botanists and others who required material for their research in wood structure, but Watkins himself, over a tenure of 43 years, did not carry out any research based on the wood specimens. His major contribution to the Smithsonian Institution was designing the exhibit hall noted above over which he held domain until it was demolished in 1960 at the time of his retirement from government service.

The first collections of wood at the Smithsonian were those gathered by the botanist Henri Pittier and they came from forest trees of Panama. All were associated with herbarium vouchers deposited in the U.S. National Herbarium. For a long time, many subsequent accessions were duplicates of those at Yale, and Samuel Record kept the Smithsonian Institution well provided with specimens. In addition, many other excellent collections were catalogued, for example: B. A. Krukoff's Brazilian, West African, and Sumatran material; the Project I set of the New York State College of Forestry; the entire private collection of Archie F. Wilson; collections of José Cuatrecasas from Colombia; Llewelyn Williams' Peruvian woods; and my own collections from Panama, the Philippines, Hawaii, and Dominica.

In 1960, at the time the collection was transferred to the

Smithsonian Department of Botany, I was appointed curator of the wood collection which then numbered 15,000 specimens. The wood collection became the basis for a Division of Woods (later changed to Division of Plant Anatomy) and an active program of research in wood anatomy was begun. A modest amount of service work in identification was continued. Watkins had accumulated many thousands of duplicate wood specimens over the years and all these were distributed on exchange shortly after the commencement of my tenure. Two other staff members were added in the next several years, Richard H. Eyde and Edward S. Ayensu. When I left the Smithsonian Institution to return to university teaching in 1967, the collection of woods had grown to over 35,000 specimens. Presently, there is little research in wood anatomy *per se* being carried out in the laboratories at the Smithsonian Institution, but there is still an active program of accessioning and many blocks are sent on request to botanists and others interested in studying comparative wood anatomy. The collections are in excellent condition, carefully catalogued, and readily available to any who need them.

The wood collections housed in the Herbarium Building at Harvard University owe their origin in large part to the work of Irving W. Bailey and W. W. Tupper. In conjunction with their early studies on size variations in tracheary cells, Bailey and Tupper were obliged to amass a diverse and sizeable collection of woods upon which to base their observations. This began sometime before 1918 and accretion of specimens has continued until the present time. According to my present information, the woods obtained and used by Bailey and Tupper in their pioneer investigations were not necessarily associated with herbarium vouchers. More recently, of course, most of the accessions have consisted of wood specimens associated with herbarium vouchers many of which are deposited in the Harvard University Herbaria.

The principal activities which have centered about the Harvard wood collections have always been predominantly research-oriented. For several decades following 1918 there was a steady stream of what have proved to be the most significant and far-reaching investigations in plant evolution, based upon the study of wood anatomy, ever carried on in any institution. Not only were these investigations carried on personally by I. W. Bailey, but many of the botanists who studied at Harvard University used these specimens as bases for their own researches, both while they were students or fellows at Harvard, and subsequently. Names of these individuals represent some

of the luminaries in botany today: Wetmore, Barghoorn, Heimsch, A. C. Smith, Carlquist, Tippo, Howard, and Cheadle, and their students of the second generation. The impact of anatomical studies associated with the Harvard wood collections is difficult to assess quantitatively, but it has already had a profound influence on interpretations of plant relationships and phylogeny. No botanist interested in these aspects of study can afford to overlook or casually consider the work of I. W. Bailey and the Harvard plant anatomists.

Service work, although carried on in conjunction with the collections, was indeed second to research and publication, and teaching. It is important to note here, even though his prodigious energies were mainly directed to anatomical research, Bailey was not an intellectual snob who had no real interest in the practical aspects of his profession. For example, with H. A. Spoehr he published on the role of research in the development of forestry in North America in 1929, and a number of his early papers reflected his appreciation of the pragmatic value of woods and forests.

Specimens in the Harvard collection resulted from the quests of Bailey and Tupper in the early days, and from the collections of other botanists later on. Once the collection became established, and it was known that this was one of the major repositories for woods to be used in research and teaching, materials arrived from many sources. Albert C. Smith deposited a set of his Fiji wood specimens there, for example. A set of B. A. Krukoff's Brazilian woods is lodged at Harvard; Llewelyn Williams deposited a set of his Peruvian woods; and there is a set of the Jesup Collection woods of the United States prepared earlier under the supervision of Charles Sprague Sargent. There are groups of woods from various foreign forestry departments, particularly from Borneo and Sarawak. Unlike the Record Collection at Yale, special emphasis at Harvard was given to Asian material. Much of the publication resulting from studies of these woods appeared in the *Journal of the Arnold Arboretum*, particularly the later investigations of I. W. Bailey, his students, and co-workers.

The Harvard wood collection now numbers somewhat over 25,000 specimens of dried woods. Besides dried wood specimens, the Harvard collections also comprise fluid-preserved specimens and permanent microscope slides containing sections of wood. In a report submitted by Professor Ralph H. Wetmore to Elmer D. Merrill, Director of the Arnold Arboretum, entitled "Annual Report for the Wood Collection, Biological Laboratories"

1940–1941, there were recorded 9,324 fluid-preserved specimens, 11,857 dried specimens, and 24,382 microscope slides.

Since Bailey's retirement and death in 1967, activities both in the accumulation of specimens and in research had declined. Responsibility for the collection has devolved to the present Director of the Arnold Arboretum, Richard A. Howard, and it is through his good offices and personal interest in plant anatomy that specimens are made available to botanists on request for their own researches in comparative plant anatomy.

If we examine the present status of the six major wood collections of a few years ago, the first observation to make is that Yale's Record Memorial Collection and the Field Museum Collection no longer exist as such. Secondly, the research, education, and service activities associated with the Brown Memorial Collection, the Smithsonian Institution collections, and the Harvard collections have diminished over what they were a relatively few years ago. This leaves the collections of the U.S. Forest Products Laboratory, recently augmented by the additions of wood specimens from Yale and from the Field Museum. But, even here, where the traditional emphasis has been on service, the two-man professional staff is hardly able to care for the many curatorial responsibilities and at the same time to provide necessary service to the public and industry. Naming an institution a "Center for Wood Anatomy Research" does not in itself bring one into being. The plain fact of the matter is that wood collections and their associated activities are not being fully supported by the institutions of which they are a part.

There is some argument for a continued consolidation of wood collections, such as has recently taken place at the Forest Products Laboratory, and on the face of it, it seems eminently logical: greater resources in terms of specimens, expanded services and research through increased staff, heightened productivity through enlarged physical facilities — laboratories, libraries, workshops, and the like. There are also cogent arguments against consolidation: centralization raises the possibility of control; destruction of all resources through natural or manmade catastrophe is more likely; research carried on in a single institution is more conducive to channelization.

All of this is academic wool-gathering when we view today's trends in the upkeep of collections of all kinds, not just wood collections. It is a fact that there is a growing impetus for different types of institutions to transfer their study collections to other institutions, owing not only to lack of funding and the related problem, lack of space, but to a lack of interest on the

parts of practitioners to continue the kinds of activities which were once associated with the collections. I maintain that if the practitioners were deeply interested in the collections and dedicated to using them as bases for service, research, publication, and education, institutions would make adjustments to enable the continued maintenance of the collections for the purposes noted above. Basically, it is lack of involvement with the collections that permits administrators to temporize and to cast greedy eyes on space occupied and monies expended, both of which can always be diverted to other "more pressing" needs.

The activities which surround wood collections are subject to the same human whims which accompany any other endeavor. What is exciting today fails to excite our followers. There is inherent glamour in new fields of effort and in new methods, despite the fact that older lines of effort and approach are far from being exhausted and yet have much to yield. We seem always to be seeking the untapped vein when present veins are still ripe with unexplored potential. Thus, the halcyon days, when H. P. Brown, S. J. Record, and I. W. Bailey were pursuing their studies of wood based on their collections, have become attenuated and we find ourselves at a crossroad. We may ask ourselves: what should be the future of wood collections? Do they indeed have a future? Where can they exist and still serve their traditional functions while promoting expansion into new avenues of endeavor?

At this point I must admit my total bias toward the maintenance of wood collections and the continuation and enhancement of scientific activities based upon them. Wood collections represent the only preserved, unadulterated, and uninterpreted sources of facts through which it is possible to study the construction of the axis of the woody plants which clothe much of the surface of the earth. If we were only and exclusively concerned with the maintenance of wood specimens as a record or hedge against the present rapid diminution of our natural resources, I would say this is reason enough to keep these collections as a form of evidence of the natural products of the earth. But, of course, this would be a narrow view; nevertheless, I believe it to be valid and supportable if we but look into the future with an eye on the past.

Except where wood collections exist primarily to serve the public need, they have flourished owing predominantly to the interest and dedication of single persons: H. P. Brown, I. W. Bailey, and S. J. Record, for example. What was lacking then and what is lacking now, is institutional appreciation of wood

collections and institutional commitment to their maintenance. Admittedly, these are frail requirements, but at least they are superior to the commitments of men who, after all, are shorter-lived than institutions. The great museums have the best records for institutional commitment, but as we have seen, even these are not immutable. In the final analysis, then, we can only trust to good faith, the wisdom of administrators and scientists, and chiefly a concern for the future, for the continued existence of wood collections, or for that matter, any other organized collection of natural and cultural products.

One may reasonably ask then, where can wood collections and allied activities be supported in the most favorable environment? I believe the answer to this question depends on the activities which are associated with the wood collection, and not on the collection of woods, as such. I will be frank to admit that service work, in the form of identifications, is a price one pays for being affiliated with any collection. However, unlike the determination of herbarium specimens, bird skins, or mammal pelts, the act of identifying a wood specimen is not a totally satisfying experience, at least not to me. A wood specimen, at best, is only a fragment of an organism and the most accurate identification of the plant from which it was derived really depends on a determination made from a complete herbarium specimen. So, identifying a piece of wood lacks the pleasure attendant upon the identification of a herbarium specimen, and thus the species of plant.

It is true that wood identification can be extremely important commercially and forensically, and it is often a major ethnobotanical and paleobotanical tool. But, many of the pieces of wood for which identification is required as a service come from curiosity seekers wanting to know the name of a bit of driftwood picked up on the beach during a summer vacation or uncovered in a garden. There should be a place where this kind of wood collection-associated activity can be carried on, and that place is probably a government-supported agency such as the U.S. Forest Products Laboratory. Indeed, as noted above, service of this kind has been the mainstay of activity in the wood collection at the Forest Products Laboratory, and I believe, as far as wood collections are concerned, that the Laboratory can perform its greatest service to the public and to industry by continuing this type of effort.

Scientific research, publication, and education associated with wood collections, I believe are carried out most effectively in the inquisitive and stimulating atmosphere of the university,

well apart from directed research and service-oriented drudgery. Ideally, the wood collection should find its most sympathetic support in an institution which has some kind of commitment to the study of trees and other woody plants; that is, an arboretum, botanical garden, a department of botany, or a school of forestry. Thus, we have found in the past, in the United States the most active research in wood anatomy has taken place within the university milieu, at the Yale School of Forestry, at the New York State College of Forestry, and at Harvard University with its Arnold Arboretum and program of study in forest trees. Professor Laurence Chalk's work prospered at the Imperial Forestry Institute at the University of Oxford in England. It is also worth pointing out here that other important programs of research in wood anatomy have been associated with non-university botanical gardens, for example, at the Jodrell Laboratory, Kew, and at such museum-oriented organizations as the Smithsonian Institution. It is up to the staff members of these organizations where there has been a commitment to the study of woody plants and where there is a framework already in existence in terms of a wood collection, to reinvigorate and revitalize research and education in wood anatomy. Lest I am accused of being a wood anatomy bigot, let me hasten to say that I do not believe that studies in wood anatomy can remain viable in a vacuum; rather, they must be integrated with other studies in plant anatomy and with other phases of botanical endeavor.

Assuredly, it is incumbent upon individual botanists to dedicate themselves to the achievement of commitments from institutions concerning wood collections, their associated activities, and their continued existence and increase. Without sincere, vigorous, and persistent involvement of botanists, the present trend toward consolidation of wood collections will swell concomitantly with attrition in basic scientific research. And all that will remain among the ashes will be the mundane service activities required to provide identifications for the curious public, for government, and for industry.

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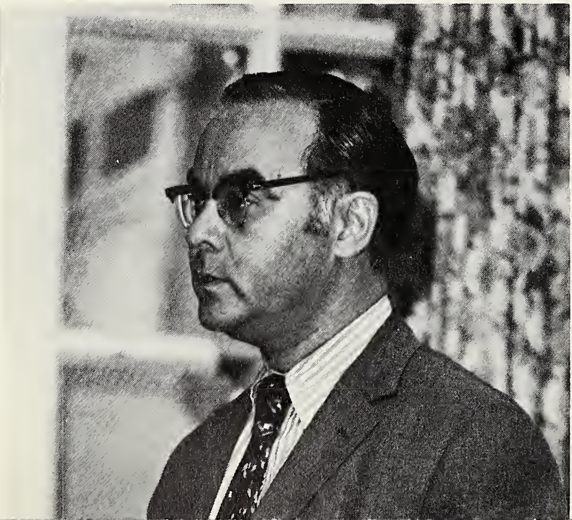


Eastern North American Plants in Cultivation

Many indigenous North American plants are in cultivation, but many equally worthy ones are seldom grown. It often appears that familiar native plants are taken for granted, while more exotic ones — those with the glamor of coming from somewhere else — are more commonly cultivated. Perhaps this is what happens everywhere, but perhaps this attitude is a hand-me-down from the time when immigrants to the New World brought with them plants that tied them to the Old. At any rate, in the eastern United States some of the most commonly cultivated plants are exotic species such as *Forsythia* species and hybrids, various species of *Ligustrum*, *Syringa vulgaris*, *Ilex crenata*, *Magnolia* × *soulangiana*, *Malus* species and hybrids, *Acer platanoides*, Asiatic rhododendrons (both evergreen and deciduous) and their hybrids, *Berberis thunbergii*, *Abelia* × *grandiflora*, *Vinca minor*, and *Pachysandra procumbens*, to mention only a few examples.

This is not to imply, however, that there are few indigenous plants that have "made the grade," horticulturally speaking, for there are many obvious successes. Some plants, such as *Cornus florida*, have been adopted immediately and widely, but others, such as *Phlox stolonifera* 'Blue Ridge' have had to receive an award in Europe before drawing the attention they deserve here, much as American singers used to have to acquire a foreign reputation before being accepted as worthwhile artists. Examples among the widely grown eastern American trees are *Tsuga canadensis*; *Thuja occidentalis*; *Pinus strobus* (and other species); *Quercus rubra*, *Q. palustris*, and *Q. phellos* (the last primarily in the southeastern United States); *Acer rubrum*, *A. saccharinum*, *A. saccharum*, and *A. negundo*; *Gleditsia triacanthos* (particularly some of the thornless staminate cultivars); *Magnolia grandiflora*; and *Ulmus americana* (certainly one of the most widely planted trees in the northern United States, but one that is severely threatened by the "Dutch" elm disease). *Cornus florida* and *Cercis canadensis* are, with doubt, two of the most ornamental and widely planted of all eastern Ameri-

can small trees. Among other woody plants can be cited *Ilex opaca*, *Leucothoë fontanesiana*, *Pieris floribunda* (mainly in the North, for it is little planted in the southern Appalachians where it is indigenous), *Hydrangea arborescens*, *Kalmia latifolia*, and *Campsis radicans*. Herbaceous plants include *Phlox paniculata*, *P. subulata*, and the annual *P. drummondii* (all three in numerous color forms), *Phlox divaricata*, *Aquilegia* species and their hybrids, and various species of *Tradescantia*, *Oenothera*, *Coreopsis*, *Gaillardia*, and *Aster*. And, of course, some of the plants derived from Mexico, such as *Tagetes*, *Zinnia*, *Cosmos*, and *Dahlia*, are almost ubiquitous garden plants. But who in the United States would cultivate any of the goldenrods (*Solidago* species), which are colorful garden plants in England; or who would plant *Rhus typhina* as an ornamental shrub, as it is grown in Switzerland; and who would deliberately cultivate *Ipomoea* in the Southeast, where several species are among the most aggravating garden weeds? All of these are much too familiar.

Rehder's *Manual of Cultivated Trees and Shrubs* (ed. 2, 1940) includes some 2535 species of woody plants in 486 genera that are in cultivation in one way or another in northeastern North America. Of these, 1047 species in 228 genera are indigenous to the continental United States. Obviously, it is impossible with an allotted time and space to consider even these, much less the herbaceous ones, in any detail. It seems most practical here to deal primarily with plants of eastern North America (those with which I am most familiar), without meaning to slight the contributions of the western part of the United States and Canada, Meso-America, or the West Indies, all important sources of cultivated ornamental plants. I must also restrict these comments to eastern North American plants as cultivated in the United States without much consideration of those cultivated in other countries. Within this limitation I shall comment briefly on a few of the future potentials of botanical gardens and arboreta in connection with the cultivation of native plants as ornamentals. Some of these ideas are already familiar, but among them may be some that will suggest some directions that are open for work with native plants under cultivation.

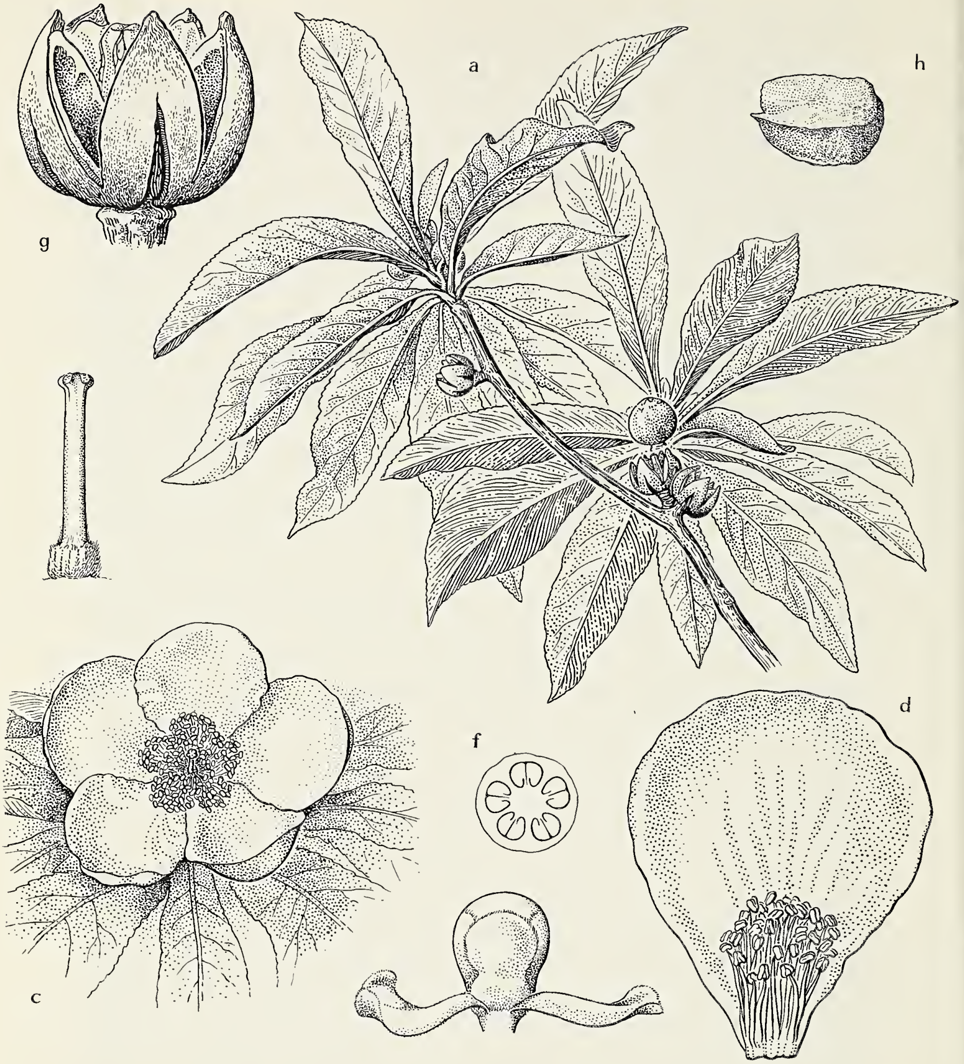
Conservation of Species. Certainly it is most desirable to preserve wild populations of each plant species in its own habitat through conservation of whole ecosystems in as many parts of the world as possible. Wild populations and their interactions

with other organisms are far better for study, research, and admiration than those in cultivation where only a few individuals can be preserved (and then largely under artificial conditions). It seems likely, however, that in view of the wholesale modification of large areas of the earth some species will survive only in botanical gardens or arboreta, in some instances far removed from the natural distribution of the species.

In North America, the most conspicuous and well-known example is *Franklinia alatamaha*, which was known from a single colony near what was Fort Barrington, in McIntosh County, Georgia. It was last seen in the wild in 1803; nurserymen attempting to fill orders for the plant may have played a crucial role in its disappearance. No other colony has ever been found, and *Franklinia* now survives only in cultivation. Other rare plants that may meet a similar fate are the handsome red-flowered mint *Conradina verticillata*; the rare *Gentiana pennelliana*, of western Florida; *Lilium iridollae*, of the same region; and *Lindera melissifolia*, and *Kalmia cuneata*, two of our rarest shrubs.

Other plants endangered by man through his careless introduction of disease-producing organisms include *Castanea dentata*, formerly one of the dominant trees of the eastern deciduous forest. The chestnut still survives but hardly ever fruits in its native habitat, for the sucker shoots which spring from the roots are usually attacked by the blight organism, *Endothia parasitica*, before they are large enough to flower. Outside its original eastern American distribution and beyond the reach of the blight, the tree still flourishes, flowers, and fruits under cultivation, as, for example, in northern Michigan and in Portland, Oregon. It seems likely that a similar or even more serious fate may be in store for *Ulmus americana*, since, as yet, no individuals truly resistant to the disease caused by *Ceratocystis ulmi* have been found, in contrast to the European elm, *Ulmus procera* (also affected by the fungus but not so severely), which apparently is making a comeback in Europe. It seems likely that both *Castanea dentata* and *Ulmus americana* will survive primarily in botanical gardens and arboreta well removed from the sources of infection.

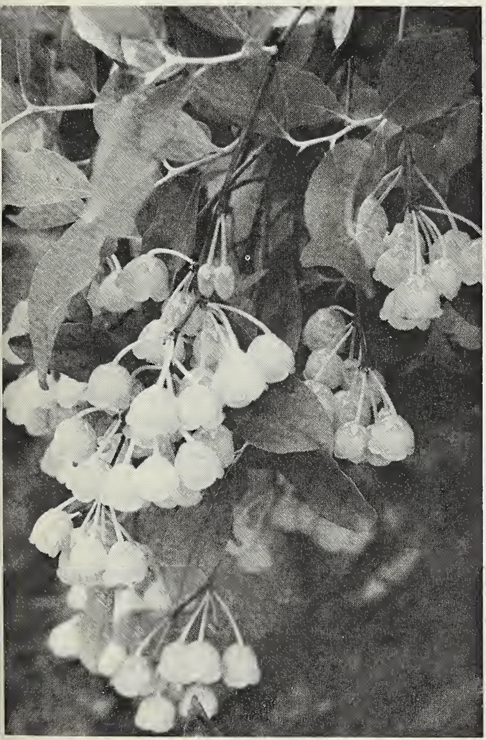
Promotion of Desirable but Seldom Cultivated Plants. In spite of Rehder's inclusion of over a thousand species of trees, shrubs, and woody vines in his *Manual*, it is evident that many of these are seldom encountered in cultivation outside botanical gardens and arboreta. Botanical and horticultural institutions

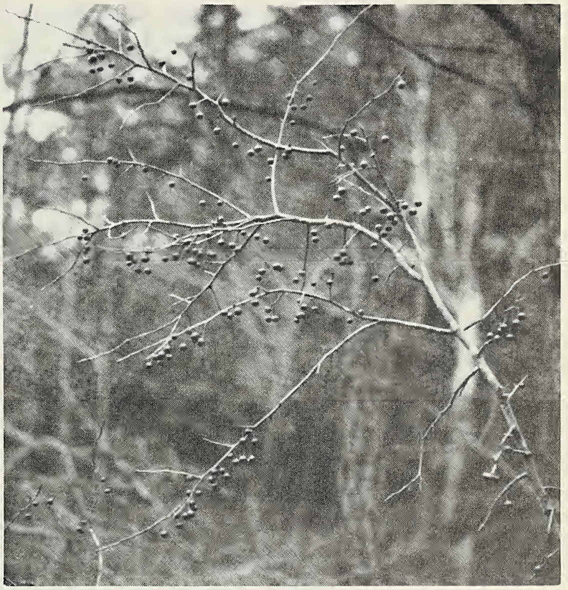


Franklinia alatamaha. *a, branch before flowering, bearing fruit of two preceding years, × 1/4; b, bud showing outermost sepal and two bractlets, × 1; c, flower, × 1/2; d, petal with group of stamens attached, × 1; e, gynoecium (pistil), × 2/3; f, diagrammatic cross section of ovary, showing two rows of ovules in each locule, × 5; g, capsule from which seeds have been shed — note loculicidal dehiscence above, septicidal dehiscence below, × 2/3; h, seed, the hilum to upper left. (Drawn by the late Dorothy H. Marsh from specimens cultivated at the Henry Foundation for Botanical Research and the Arnold Arboretum. Illustration prepared for a Generic Flora of the Southeastern United States, a project made possible through the support of the National Science Foundation [currently through Grant GB–6459X, C. E. Wood, Jr., principal investigator].)*

should make special efforts to bring knowledge of such neglected plants to the horticultural public and to promote their cultivation, for there are many worthwhile ornamental plants that fall into this category. Among these are the witch-hazels, *Hamamelis virginiana* (fall flowering) and *H. vernalis* (winter or spring flowering and in shades of deep red to yellow); *Cladrastis lutea*, yellow-wood, notable for its *Wisteria*-like clusters of white flowers in early summer; our only ericaceous tree, *Oxydendrum arboreum*, sourwood, outstanding in its panicles of small white flowers in summer and brilliant coloration in autumn; *Ilex longipes* and *I. decidua*, two handsome deciduous hollies; *Neviusia alabamensis*, a rare rosaceous shrub with flowers lacking petals but with showy white stamens; *Fothergilla major*, an apetalous relative of *Hamamelis* with conspicuous stamens and leaves with brilliant red and yellow autumn color; the brilliantly colored *Rhododendron speciosum, R. cumberlandense, R. prunifolium, and R. bakeri*; the white- or pink-flowered *R. atlanticum* and *R. canescens*; *R. minus*, the Piedmont counterpart of the more frequently grown *R. carolinianum*; the pink-shell azalea, *R. vaseyi*; the deciduous magnolias, such as *M. macrophylla, M. ashei, M. cordata* (particularly the yellow-flowered forms), and the pair of close relatives, *M. fraseri* and *M. pyramidata*; the red-flowered *Aesculus pavia* and the shrubby *Ae. parviflora* with its candle-like racemes of white flowers; the silverbell trees, *Halesia diptera* (particularly the showy var. *magniflora*), *H. parviflora*, and the very variable *H. carolina* (including *H. monticola*); *Lonicera flava* and the more frequently cultivated coral honeysuckle, *L. sempervirens*; the shadblows or shad-bushes, *Amelanchier arborea, A. canadensis*, the dwarf *A. stolonifera* and *A. obovata*, and other species; *Yucca glauca*, some forms of which are hardy far beyond its natural distribution; *Ungnadia speciosa*, of the Sapindaceae, a pink-flowered shrub known as Texas buckeye that has proved to be hardy as far north as Gladwyne, Pennsylvania; *Pinckneya bracteata*, notable for the one or two pink enlarged sepals of each flower; *Cyrilla racemiflora*, mentioned below; *Leucothoë racemosa* and *L. recurvata* and *Clethra alnifolia* and *C. acuminata*, of the Ericaceae, two vicarious Coastal Plain-montane species pairs; *Elliottia racemosa* with its racemes of white flowers; *Zenobia pulverulenta*, with its bell-shaped white flowers and leaves either whitened or green below; *Stewartia ovata* and the equally showy but much less hardy *S. malacodendron*; *Styrax americana* and *S. grandifolia*; various species of *Vaccinium* and *Gaylussacia*; and a host of herbaceous species, among which are *Amsonia*

Hamamelis vernalis. *Photo: J. Henry.*





Top left: Rhododendron speciosum
right: Halesia monticola

Bottom left: Zenobia pulverulenta
right: Ilex longipes

Photos: J. Henry

species, *Baptisia sphaerocarpa, Ipomopsis rubra, Phlox bifida, Camassia scilloides, Zephyranthes atamasco, Hymenocallis* species, *Hesperaloë parviflora* (the red-flowered yucca, from central Texas but perfectly hardy at Gladwyne), various species of *Clematis*, and the gray-leaved *Senecio antenariifolius* and the showy yellow-flowered *Eriogonum allenii*, both endemics of the Virginia and West Virginia shale barrens that flourish in open, dry situations as long as they are not shaded out by surrounding plants. The list could go on and on.

Selection of Unusual Forms from Wild Populations. A reservoir that still has an enormous horticultural potential is the natural variability of wild populations. The late Mrs. J. Norman Henry brought together over a period of years a remarkable collection of native plants, especially from the southern and southwestern United States. These she grew (most far to the north of their native habitats) at Gladwyne (near Philadelphia), Pennsylvania, where they and others are maintained for study and distribution by the Henry Foundation for Botanical Research, which she established. In the course of her extensive field work she brought into cultivation most of the species mentioned in the preceding paragraph and also made many interesting selections that deserve to be known better. These include intense color forms of *Rhododendron speciosum, R. cumberlandense, R. bakeri*, and *R. austrinum*; a hose-in-hose form of *R. alabamense*; a yellow-fruited form of *Ilex decidua*; a form of *I. glabra* that has maroon fruits until winter when they become black, as in the kind usually seen; *Phlox nivalis* 'Gladwyne' and 'Azure', *P. carolina* 'Chattahoochee', *P. stolonifera* 'Blue Ridge'; handsome natural hybrids of *Aesculus pavia* with *Ae. sylvatica* and with *Ae. glabra*; a red-flowered form of the cross-vine, *Bignonia* (*Anisostichus*) *capreolata*; a number of color variants of *Lilium superbum* and *L. canadense*; a beautiful late-flowering *Robinia*, a small tree with densely gray-pubescent leaves and compact drooping racemes of pink flowers, distinctive enough to be given specific rank, except that it appears to be a natural sterile hybrid of unknown parentage; a pale orange-flowered *Campsis radicans*; a startling number of puzzling variants of eastern American *Yucca*; and several variants of *Calycanthus floridus*, including a green-flowered one — all valuable additions to horticulture.

Still other examples are seen in the numerous cultivars that have been selected from wild populations of *Ilex opaca*. Currently Mr. and Mrs. Don Smith, of the Watnong Nursery, New

Jersey, have been bringing into cultivation a number of excellent forms of *Gaylussacia brachycera* and of *Leiophyllum buxifolium.* Further examples are among the cultivars recently registered at the Arnold Arboretum (Arnoldia 30: 251. 1970): *Cercis canadensis* 'Royal White' (larger white flowers than usual in form *alba*) and 'Silver Cloud' (variegated leaves), *Cornus stolonifera* 'Isanti' (dense, compact growth), *Liriodendron tulipifera* 'Ardis' (miniature in leaf and growth), and *Tsuga canadensis* 'Watnong Star' (dwarf, the new growth very pale at first).

Acer rubrum, with its great variability in intensity of flower and fruit color, as well as in autumn coloration; *Robinia*, which hybridizes extensively in the southern Appalachians producing a wide variety of attractive clones that vary in height of plant and size and color of flower; the polymorphic *Vaccinium stamineum* and its relatives, a taxonomic nightmare, but with much variation that can be of horticultural interest; and *Magnolia grandiflora*, with its variable flower size, color of new foliage, pubescence of the underside of the leaves, and stature (including dwarf forms), are all taxa that could yield desirable cultivars.

A slightly different sort of selection that can be tried with other plants is seen in Burpee's 'Gloriosa Daisy', which is an artificial tetraploid derived from color forms of the common and widespread black-eyed susan. By selecting forms that are "double-flowered" or have the inner half of each ray floret brown instead of orange-yellow and then doubling the chromosome number by treatment with colchicine, Burpee's plant breeders produced a much more vigorous, much larger flowered plant that is more showy than and far superior to the wild *Rudbeckia serotina.* One wonders how other members of the Aster Family, e.g., *Gaillardia*, with its polymorphic corolla forms and colors, or members of several other families might respond to similar treatment.

Still another type of selection is going on at the Arnold Arboretum, where Mr. A. J. Fordham is growing seedlings from cones on "witches' brooms" from various conifers. Each witches' broom represents a genetic mutation that has occurred on a growing branch of a tree, the resulting growth having a compact, bushy, stunted, or dwarfed appearance. Seedlings from cones produced on branches of this type yield about half "normal" individuals and half variously dwarfed ones. Selections from the latter group provide slow-growing genetically dwarf plants that are useful for bonsai, or in rock gardens or other

Magnolia ashei. *Photo: J. Henry.*

places where a low, slow-growing plant is desirable. (See Bonsai Bull. 6: 6–11. Fall 1968; 6: 9–14. Winter 1968–69.)

Selection of Ecotypes. Still another type of selection from wild populations that botanical gardens and arboreta should continue is the search for physiological variants or ecotypes suited to various climatic extremes, e.g., for hardiness in northern areas, or to various soil types. In this connection, it is always necessary to remember that one can be quite mistaken in prejudging the physiological potentials of any plant. Thus, although *Franklinia alatamaha* came from the warm climate of the Coastal Plain of Georgia, it is hardy as far north as Boston; and there has been for many years on Bussey Hill in the Arnold Arboretum a plant of *Cyrilla racemiflora*, a species that is not found in the wild north of southeastern Virginia. One can surmise, however, from what is already known of the ecotypic variation in plant species, that, in any wide-ranging species, the

individuals comprising populations in various parts of its range will be genetically (hence, physiologically) adapted to various climatic extremes, as well as to various soil types, and selections can be made accordingly.

Many of the woodland plants of eastern North America have very broad distributions: a very commonly encountered one extends roughly from Quebec, west to Minnesota or southern Saskatchewan, and south to eastern Texas and to Florida. Among the populations of a species distributed so broadly, it is likely that there is a considerable amount of ecotypic differentiation and that the more northern populations consist of individuals more tolerant of cold than those of the more southern ones. Search for various ecotypes suited to special environments should produce some interesting results. Wright, for instance, almost thirty years ago (Jour. Forestry 42: 489–495, 591–597. 1944) demonstrated differences in resistance to cold in white and in red ash, *Fraxinus americana* and *F. pennsylvanica*; and ecotypic variation in response to day-length has been found in species of *Populus*, *Pinus*, and *Alnus*, among others. Certainly the northern populations of white pine, *Pinus strobus*, should prove to be physiologically, if not morphologically, quite different from those in southern Mexico, and the arborvitae, *Thuja occidentalis*, of northern bogs must be physiologically different from the plants of this species that grow on dry limestone cliffs in Virginia. Indeed, J. R. Habeck (Ecology 39: 457–468. 1958) has found evidence of ecotypic differentiation between populations of *Thuja* that grow in poorly drained swamps and those on well-drained upland sites in Wisconsin.

As noted previously, *Cornus florida* is very widely cultivated, but its western counterpart, C. *nuttallii*, with six pointed bracts instead of four notched ones, has repeatedly proved to be too tender to survive the winter of the eastern United States. However, at Boyd's Nurseries, McMinnville, Tennessee, after twenty years of trials, a single seedling that has withstood −19° F., was found and this plant has now been propagated and is available commercially. Within the range of C. *nuttallii*, from southwestern British Columbia, to western Washington and Oregon, and southward in the Sierra Nevada and in the Coast Ranges of California, there must be other climatic ecotypes that would be suitable in the East. Disjunct populations of this species in central western Idaho offer particularly intriguing possibilities.

As a result of many attempts to grow southern plants at Gladwyne, Pennsylvania, Mrs. Henry evolved the general principle that the hardiest forms of species that grow on the Atlantic

and Gulf Coastal plains and in the Mississippi Embayment of the Coastal Plain are to be found in the Embayment area, where the climate is more continental (hence more rigorous) and plants are subjected to more sudden changes in temperature than on the Coastal Plain of the southeastern United States. This principle leads to the suspicion (expectation?) that hardier forms of a plant such as *Styrax americana*, which at Boston is killed back each winter, can be found in the northernmost part of its range in the Mississippi Embayment, in the case of the *Styrax* the part that lies in southeastern Missouri, western Kentucky, southern Illinois, Indiana, and Ohio.

Edaphic or soil ecotypes are also to be sought. Five very striking examples are found in shrubby races of *Quercus chrysolepis*, *Quercus garryana*, *Lithocarpus densiflora*, *Chrysolepis* (*Castanopsis*) *chrysophylla*, and *Umbellularia californica* that were reported from the Siskyou Mountains of southern Oregon and northern California by Whitaker (Ecol. Monogr. 30: 299. 1960). These forms are genetically dwarf and are adapted to growth in soils derived from serpentine, a mineral high in magnesium, while their arborescent counterparts are not. If these dwarfed races are like other plants adapted to serpentine soils, they will grow even better in richer soils, while retaining their dwarf character, and all five have interesting horticultural potentials as shrubs and even as bonsai subjects.

Search should also be made for species and ecotypes that are resistant to air pollution in cities, although, hopefully, steps are being taken to reduce this. Some plants are known to be very sensitive, others are more resistant, but I do not know whether a real search has been made for especially smog-resistant plants.

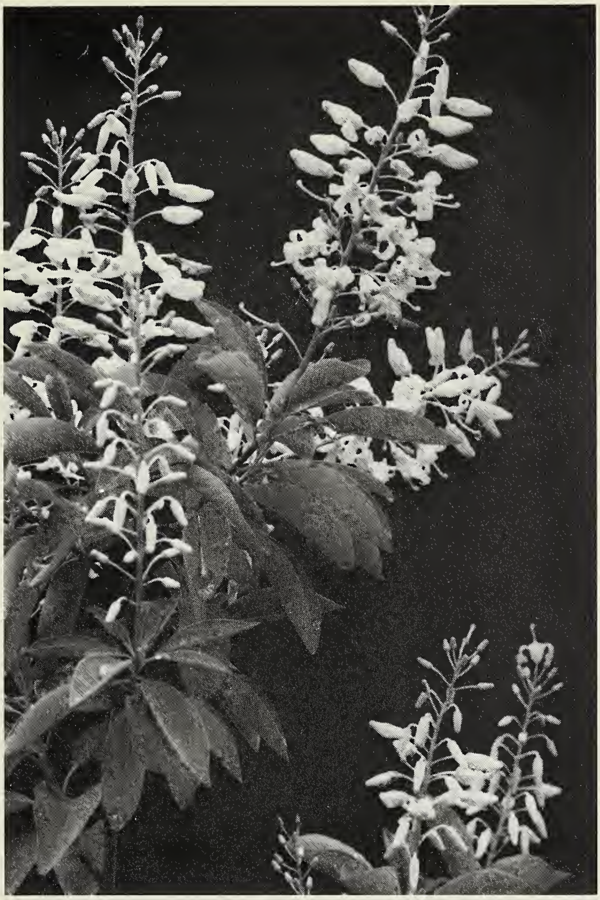
Hybridization. Both spontaneous and controlled crosses of native American plants in arboreta are far from new, but there are still enormous untouched potentials, as in the genus *Rhododendron.* The 'Ghent' and 'Exbury' azaleas are spectacular examples of complex hybrids that involve eastern American species of *Rhododendron*, but there are many other possibilities among the dozen or so species of section *Pentanthera* that occur in eastern North America. At Gladwyne, Mrs. Henry saw the desirability of extending the flowering period of azaleas into midsummer or later, and in 1953 described *R.* × *gladwynense*, the hybrid (made in 1944) between the two latest flowering species, *R. prunifolium*, with large, brilliant red flowers, and *R. serrulatum*, with small white flowers. At Gladwyne, the hybrids bloom from mid-July to mid-August, or later, and have proved to

Stewartia malachodendron. *Photo: J. Henry.*

be quite hardy. Mrs. Henry later crossed *R.* × *gladwynense* with the earlier-flowering *R. arborescens* and made a number of other beautiful hybrids. Fred C. Galle, at the Ida Cason Calloway Gardens, Pine Mountain, Georgia, and Henry T. Skinner, of the U.S. National Arboretum, are currently producing a series of hybrids involving these and other American azaleas.

The use of American species as a source of hardiness in hybrids is well known, as with *Rhododendron catawbiense*, which has provided the hardy genetic background of many red-flowered hybrid rhododendrons, or as with the white-flowered *Nymphaea odorata* in crosses with tenderer species of *Nymphaea* with colorful flowers. Such work could well be extended to other genera. Crosses between *Hydrangea arborescens* and its closest relative, the less hardy blue-flowered *H. aspera*, of Japan, might produce interesting results, as might the hybridization of *Aesculus pavia* with *Ae. turbinata*, of Japan, or other species, such as *Ae. parviflora*, which is placed in a section of its own. (The handsome pink-flowered *Ae. carnea* is a tetraploid that originated through hybridization of *Ae. pavia* and *Ae. hippocastanum*, which belong to different sections.) It would also be interesting to see what results could be obtained in crosses between *Ceanothus americanus* or *C. sanguineus* and some of the blue-flowered western American species that are not adapted to the climate of the eastern United States.

Problems in the Cultivation of Native Plants. Finally, there is much to be learned about many aspects of the cultivation of native ornamental plants. The seed-germination requirements of many of the tree species are well known, but those of many shrubs and of the majority of herbaceous plants have received relatively little attention. There are also numerous problems in connection with the vegetative propagation of native plants. Difficulties in rooting cuttings of American azaleas (*Rhododendron* sect. *Pentanthera*) worked against the propagation and wide horticultural use of these beautiful plants until the discoveries that cuttings should be taken early in the growing season when the new shoots are just beginning to become woody and that root-suckers can also be taken made the rooting of cuttings a routine matter (see A. J. Fordham, Quart. Bull. Amer. Rhododendron Soc. 23: 162–165. 1969). The further discovery that *Elliottia racemosa* will produce root-suckers that can easily be rooted has eased the difficulty of propagating that beautiful ericaceous endemic of Georgia (see Fordham, Arnoldia 29(3): 17–20. 1969). Yet, plants such as *Nyssa sylvatica* and *Sassafras*



Elliottia racemosa. *Photo: J. Henry.*

albidum, each of which suckers from the roots but is difficult to propagate vegetatively or to transplant, offer further problems.

These examples suggest some of the possibilities that workers at botanical gardens and arboreta can find in native eastern American plants, both in and out of cultivation. Aside from these considerations, however, but basic to all that has been said, is the question of why anyone should bother to cultivate non-food plants at all. I think that the answer lies in the satisfy-

ing connection that plants make with the natural world around us, for there is every indication that man needs to keep in contact with the living world in which he evolved. With ever-increasing urbanization and with the profound changes man is bringing to his environment, cultivated plants are more important than ever in bringing a sense of appreciation for and a sense of the value of the remarkable organisms that inhabit the earth. Man removed to an artificial world would be a sorry animal indeed. Botanical gardens and arboreta have a critical role to play in maintaining and developing a real appreciation for the natural world and our proper place in it.

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The History of Ornamental Horticulture in America

Horticulture is the art or science of growing flowers, fruits and vegetables. At one time in the early history of this country it was not differentiated from agriculture, but now, as has been the tendency in many other areas, specialization in the study and use of plants has resulted in the field of horticulture itself being divided into several sub-divisions; namely, pomology, olericulture, floriculture, ornamental horticulture and viticulture. Today there is a fascinating potential for arboreta and botanical gardens in the field of ornamental horticulture.

Ever since colonial days, the economic phases of horticulture have been given prime attention. The early colonists had to grow the vegetables and fruit trees in order to provide food. As more and more plants were established, more interest was taken in new and higher yielding varieties, then in better ways to grow these varieties and to control pests which began to infest them. Near the end of the last century, public institutions supported by federal and state tax income took up intensified experimentation in pomology and olericulture, and later viticulture and floriculture. Many excellent local state and federal stations of experimentation were established, not only to better the quality of the food produced, but also to improve the methods of producing it.

Ornamental horticulture has been a late comer in all this experimentation, and until recently the emphasis has always been on the economic phases of growing plants. This is probably as it should be. At first large estate owners would collect a lengthy list of varieties of apples, or peaches, but usually the owner did not have suitable scientific background for gaining the most information from such collections. It was frequently a personal hobby, and when he lost interest, or finances became tight, the collection was removed. Great collections of apple, pear, grape and peach varieties have now been made at our state and federal experiment stations where there is impartial experimentation by trained scientific observers. In general, little

attention has been given to the ornamental plants that we now consider so essential to beautify the world within which we live. It is here that the arboreta and botanical gardens have their opportunities. They have the large collections of all kinds of plants, those of only botanical interest and those of purely ornamental interest. The experiment stations cannot give such collections space nor proper care. On the other hand, the arboreta and botanical gardens do not have space for large collections of economically important varieties of fruits and vegetables.

Hence as far as horticulture is concerned, our interest is best confined to the ornamental aspects of horticulture. Certainly we who have had to do with arboreta and botanical gardens are far better endowed to deal with the problems which this field presents and let the government experiment stations deal with the economic fruits and vegetables.

When the early settlers first came to America, they were primarily interested in hewing a home from the forest primeval. They brought many seeds and even plants of the fruits, vegetables, herbs and flowers that they were accustomed to in their European environment. The peach, for instance, was brought by the early Spanish explorers, and in the early history of Georgia and Alabama the Indians were known to have grown many different kinds of peaches (all seedlings) which they would use in barter.

Those settlers with large land grants in Virginia were first interested in growing and selling as much cotton, tobacco, or indigo as they could. It was not until this was accomplished that they began to have more leisure and take the time to plant flowers, trees and shrubs for ornament. The earliest writings about plants in America were those by physicians who were interested in herb collections, for medicinal purposes, or by naturalists who were interested in exploiting the plants of the New World.

Prior to 1750 there were the excellent plantings of the gardens of colonial Williamsburg, where living had reached a luxurious level. Many of the plants used here were American natives as well as those brought over from England. It was not until about 1770 that we have the first treatise on American flower gardens written by a Mrs. Martha Logan of Charleston, S.C. The first American book on gardening was by Robert Squibb, the *Gardener's Kalender* published in Charleston, S.C. in 1787.

However, things were happening elsewhere as people found more and more leisure to plant ornamentals. John Bartram's garden was established in Philadelphia in 1728 and although the economic side of horticulture was his prime motive, never-

theless his garden held great interest for land owners of estates who soon became his customers.

After the fighting of the Revolutionary War was over, George Washington himself set a splendid example by settling down at Mount Vernon and planting his gardens. Thomas Jefferson was also a garden enthusiast and made no bones about where his interests were. He is generally given credit for sowing seeds of *Cytisus scoparius* along the roadsides of Virginia whenever he had to take a trip somewhere, and it may well be that naturalized stands of this European plant now found in Virginia were the results of his efforts. Land owners in New England were becoming more and more interested in ornamental gardening, for here some who had large collections of apple or pear varieties soon took up a new interest in ornamentals. If any specific time can be designated as the period when horticulture began to emerge as distinct from agriculture, it might be in the early 1800's.

Grant Thoburn established the first seed store and florist shop in New York in 1802 while Bernard M'Mahon established his in Philadelphia in 1806. Joseph Breck established his in Boston in 1818. M'Mahon listed over 1000 different kinds of plants and seeds, many of them among the best of European importations. Interest was such in New England that the Cambridge Botanic Garden was established in 1808 and this naturally became a source of great interest to plantsmen of the area. Many nurserymen started into business at about this time — William Prince in 1837. The nursery eventually was to be owned by three generations of the family. William Prince was so interested in obtaining new plants for his customers that he wrote a form letter, in the 1820's, to sea captains asking their assistance in bringing back to him small amounts of seeds or bulbs of plants native about the ports they visited. Parson's Nursery was established in 1838 on Long Island, not far away from the Prince Nursery. Such nurseries, and many others did much to make it possible for home owners to obtain new ornamental plants.

The founding of the Massachusetts Horticultural Society in 1829, and of the Pennsylvania Horticultural Society in Philadelphia shortly before, were two events which gave ornamental horticulture a greater impetus than anything else. It was through the "exhibitions" produced by these Societies that many of the ornamental plants first became known to the public. Even at the first exhibition, staged by the Massachusetts Horticultural Society, prizes were given for the best American holly, *Magnolia*

glauca, *Rhododendron maximum*, and *Kalmia latifolia*, all of which were native plants, as well as for tulips, Chinese chrysanthemums, hyacinths, carnations and roses. In 1830, there were 30 varieties of *Ranunculus asiaticus* displayed; a little later, large collections of dahlias, but the emphasis at those early exhibitions was always on fruits. The first exhibit of Indian azaleas was in 1835.

It is interesting to note in the history of the Society that even in 1841 ladies were not admitted to the dinners of the organization, for "if they were, wine could not be". In 1830 there was a great discussion against giving any lady horticultural honors for it was said that women in the garden had brought trouble since the time of Adam. No lady read a paper before the Society until 1880. However, there were indications of a change in perspective for one report read after the Committee on visiting gardens had found a Mrs. Fay at work in her garden — "what a pity that so few ladies of our land imitate her example, inhaling the fresh breath of the young day and the envigorating aroma of the freshly turned earth, planting the roses of health in their cheeks and nurturing the germs of health and strength and buoyancy of spirit".

In an exhibition staged in 1845 it was noted that there were 33 bouquets of flowers from 8 contributors, and later President Wilder of the Society was moved to note an improvement in the "arrangement" of the flowers exhibited. What would these "arrangers" have thought if they could have seen some of our modern flower shows?

By 1850 there were indications of greater interest in ornamentals than in fruits and vegetables, for in that year the Society allotted $650. in prizes for flowers, $450. for fruits and $150. for vegetables. Usually however the displays of fruits and vegetables eclipsed those of flowers. In 1856 there was a display of 40 varieties of fuchsias, underwriting the fact that by this time many a New England estate owner also had his own greenhouse. Andrew Faneuil built the first, on Tremont Street between Pemberton and Beacon, in 1715.

Mr. H. H. Hunnewell of Wellesley was a great grower of rhododendrons, and a staunch supporter of the Massachusetts Horticultural Society as well. He underwrote a large display of rhododendrons (under canvas) on the Boston Common in 1873 and this was the first time so many people had been able to see such magnificent plants in full bloom. This, and the Centennial Exhibition in Philadelphia (1876) where 1500 rhododendrons were exhibited by Waterer's Nursery of England were chiefly re-

Cytisus scoparius. *Photo: Heman Howard.*

Kalmia latifolia. *Photo: D. Wyman.*

sponsible for bringing these supposedly hard-to-grow shrubs to the attention of the general public.

There had been large collections of plants, privately owned, where the public was invited on occasion, like the collection owned by Pierre S. du Pont at Kennett Square, Pa., later to be opened and called Longwood Gardens in 1937. Then there was Shaw's Garden in St. Louis, Mo., later to be called the Missouri Botanical Garden, and the Hunnewell estate in Wellesley, Mass., later to be known as the Walter Hunnewell Arboretum. Among the first large truly public collections to be established were the Arnold Arboretum in Jamaica Plain, Mass., established in 1872; the Beal Garfield Botanic Garden on the campus of the Michigan State University in East Lansing, Michigan (1873); the Bayard Cutting Arboretum on Long Island, N.Y. (1887); Highland-Durand Eastman Park, Rochester, N.Y. (1890); and the New York Botanical Garden in New York City (1891). After these there were over a hundred others spread about the country, each one open to the public, each one displaying chiefly ornamental plants growing in the open. There is no question but what these have had a permanent effect in creating enthusiasm for ornamental horticulture by the general public. Most of these collections were started in a small way, but as funds became available more and more plants were added and the institutions concerned began using various means of presenting ornamental horticultural information to the public.

Another tremendous impetus given ornamental planting was the great influx of new plants from the Orient, chiefly as a result of exploration initiated by the Arnold Arboretum. These colorful introductions spread over nearly half a century have reached practically every garden in America. It is of interest to note that in gardens and landscape plantings of a general nature in the northern United States, half of the plants used are of oriental origin, a quarter are native to Europe and only a quarter are native to America. The colorful and exotic Japanese crab apples and cherries, tree peonies, azaleas and rhododendrons make any garden interesting.

It was during this same period that the nursery industry grew tremendously. New nurseries were formed in every state of the Union. Many an old established nursery found that it was more profitable to grow ornamental plants than it was to grow fruits. Vegetable sources were of course specialized seedsmen, but since 1920 there have been fewer and fewer nurserymen growing fruit trees.

Julius Sterling Morton (1832–1902) certainly should be men-

tioned as one individual who greatly aided ornamental horticulture. He conceived the idea of Arbor Day and was responsible for establishing the first one in 1872 in Nebraska, when over 1,000,000 trees were planted in that state alone. True it was at first that in the prairie states fruit trees were first thought of, but the idea quickly carried over to the planting of any ornamental tree, and now the day is celebrated nationwide with tree planting ceremonies, with ornamental trees far outnumbering the fruit trees planted.

It might be said that ornamental horticulture really came into its own at the start of the 20th century. By this time there were at least nine active state horticultural societies only two of which were in the mid-west, the others in the east. There were magazines featuring articles dealing with ornamental planting. Some of the great parks like Central Park in New York City (1858) and Durand Eastman Park in Rochester, New York (1890), had been popular places for visitors and this of course was bound to bring ornamental planting to the attention of the general public. Some state Experiment Stations were in operation; others were soon to follow.

The 20th century was a time for the rapid expansion of single plant societies, over 50 of them in all. These were national organizations with annual meetings, dues and usually a publication, devoted to the study, discussion and improvement of one special flower. The American Carnation Society (1902) and the American Peony Society (1904) were probably the first established. However, others have been coming into existence ever since and only last year the International Lilac Society was formed. Some are lacking in finances and general public interest at first, but their very formation shows that people are interested in these ornamental flowers and are willing to grow them and to take up their study and improvement as a special hobby.

By this time, the ladies have long been prominent in ornamental horticulture and in fact have actually taken over much of the garden planning and work. Their general interest in growing their own flowers, in color combinations and the exquisite effects they could obtain in the arranging of flowers have all been factors. The first garden clubs were probably a coming together of men and women interested in growing ornamentals in the garden. Soon however, the whole garden club idea was taken over by the ladies and it has been possibly the greatest factor in bringing interest in ornamental horticulture to what

it is today. One organization alone today has 387,700 members, mostly women. Their interests vary greatly from gardening, to flower arranging, to planting their communities, to conservation, to producing flower shows and awarding scholarships to deserving youngsters for college study.

The majority of the gardeners in America are now closely associated with the garden club movement. Either the garden owner is a member or certainly she has friends who are. When national movements are undertaken by these well organized and very well informed groups, the majority of the gardeners in America at least are cognizant of what is going on and many find they are participating, willy nilly!

More important is the fact that it is through these energetic people that advances in ornamental horticulture are quickly undertaken. With modern travel, radio, TV and newspapers what they are, new plants are soon heard about, new horticultural procedures are quickly passed along and enthusiasms for new and worthy projects are quickly publicized. A century ago such information was hard to come by. Today it might seem with all our horticultural publications that we are overwhelmed with too much information, but the growing of ornamental plants is a very popular project of every garden owner in America.

It should be pointed out that competition among the amateur growers is still as much an incentive as it always was — to grow the biggest or best or newest flower, then to be rewarded for it at some show or exhibition. The garden club movement naturally fosters this idea.

Ornamental horticulture has come a long way since the start of the nineteenth century. It is no longer an asset of the rich. It has become an important part of the lives of most Americans, even those apartment dwellers in the hearts of our large cities. Many individuals are now being trained to take a major part in this field.

There are at present over 60 national horticultural organizations devoted chiefly to the ornamental phases of horticulture, about 50 single flower societies, 41 libraries featuring information on ornamental horticulture and 78 institutions of higher learning offering bachelor's degrees in ornamental horticulture. There are nearly 500 gardens, experiment stations or institutions where special information can be obtained concerning the growing, care and propagation of ornamentals. Canada, because of its less populated areas, has not proceeded as fast as the United

States in these respects, but Ontario has set an excellent example with its government organized and subsidized horticultural societies, underlining the great importance of ornamental horticulture in this fast developing country.

The first gardens were of herbs because of necessity. Then the early settlers added a few plants popular in Europe, adding more of those native to America. Later there was a mixture of almost anything that was new or took a gardener's fancy. Methods of growing were passed around at first by word of mouth, then information was found in articles by experienced "growers" but not until the Hatch Act (1887) and the formation of state Experiment Stations, was there much scientific knowledge available to help amateur growers. Before this the best practices were those which apparently produced the best results.

Interests and needs changed. With the planting of great municipal public parks there was a great popularity among the rich growers for bedding plants. Only the city park systems, or those rich enough to have greenhouses and employ a gardener, could have a large geometric planting of bedding plants, for geometric designs in gardens were popular everywhere at the end of the last century.

Because of all the large estates and the fact that many Asiatic plants had not become commercially available, at the end of the last century there was a great demand for tall and fast growing trees. Some of these were *Aesculus hippocastanum, Catalpa bignonioides, Ailanthus altissima, Populus nigra italica, Picea abies*, *Salix babylonica* and two small weepers, *Ulmus glabra* 'Camperdownii' and *Morus alba* 'Pendula'. Now, although some of these are still grown, none of them is in the popular class. They are superseded by smaller trees such as the oriental flowering crab apples and cherries, as well as dogwoods and magnolias.

There have been times when "fads" seemed to capture the fancy of everyone. *Morus alba multicaulis* in 1824 was called the "silkworm" mulberry and everyone wanted to get in on the ground floor of a new industry. At the height of this craze, when thousands of trees were raised, seedling trees that normally would sell for fifty cents were bringing ten times this amount. The project as we know now proved futile, and now it is impossible to buy a single plant of this variety from a commercial nursery in the United States. *Morus alba* 'Pendula' which Hick's Nurseries of Long Island termed "the plant of the century' in the 1890's, soon became over-planted, and few are seen today.

Above: Aesculus hippocastanum

Right: Catalpa bignonioides

Photos: Heman Howard.

Salix babylonica. *Photo: D. Wyman.*

However, even the sophisticated gardeners of today are not immune. We are still "taken in" by the tubbed banana for the home with fruit advertised as "always available", with "tree tomatoes" producing crops "up to 40–60 pounds a year"; with a "new" rose bush (or a tree) that grows "to the roof of your home" in two years. To show how history can repeat itself, now 250 years after medicinal herb gardens were popular, it may well be that they will become so again. A new book will be published in England this summer by Maurice Messegue, *Of Men and Plants*, which is an autobiography of a famous "plant healer" who heals people, often miraculously, with the use of hand and foot baths (or poultices) in which certain of our common herbs are soaked. Undoubtedly this will start many gardeners scrounging around among the weeds and herbs in their gardens to find those recommended by the author as helpful when used for particular ailments, in the way he suggests.

There is still a great deal that the arboreta and botanical gardens can do for ornamental horticulture, being the youngest division of horticulture. With smaller houses, higher taxes and smaller home areas, there is now considerable interest in dwarf plants. Nurserymen formerly were not interested in many of these — they grew too slowly to make a display in time to bring a profit. Now such plants are in great demand. Many of the arboreta of the country with large collections of plants have their own propagating units where special studies can be initiated in finding better ways to propagate such plants. No experiment station has sufficient source material or funds to enter into work on this problem on the same scale as some of our large arboreta.

With large varietal collections of plants like lilacs, mock-oranges, weigelas, Japanese tree peonies and many other types, the arboretum is the best place in the country to compare the ornamental qualities of these varieties. Once their ornamental merits are established, the arboreta should publish lists of "the best" and those worthy of discarding. Arboreta across the country can combine their efforts to make such studies more valuable.

The arboretum is the best place to make accurate color chart notations of flower colors — very few such studies exist. Here the varieties are growing under similar conditions and presumably are all on an even basis environmentally for color comparison. Several of the large arboreta have their own publications and can initiate plant information by such means, but they

should also seek the cooperation of nationally circularized horticultural publications.

They should also initiate a "source list" of where rare but good plants are available. This is one of the most difficult things to do for it is never up to date, but it is the best means of making source information available to the public. Without such information of availability, varietal studies have little current value. The information, the availability of the plants, and the national publicity concerning this should all be carefully worked out and coordinated.

Arboreta with the space and the funds should have extensive breeding programs to provide better plants, with more colorful flowers and fruits, more resistant to pests, with better form or height or autumn color than those varieties available at present. New plants will continue to be found in cultivated areas and in the unexplored hinterlands, but the resources of the arboreta in their own collections are not to be ignored in this respect. We certainly do not need more plants but we can always use better plants and a widely publicized list of generally accepted (by other arboreta) discards which should be no longer grown commercially.

Ornamental horticulture has come a long way in the last 150 years. Just the production of ornamentals alone is big business. In 1950 there were 17,400 nurseries in the United States producing ornamental stock, employing 121,800 persons. The sales of ornamental stock alone amounted to $467,346,000 at wholesale prices. The number of ornamental woody plants sold (326,000,000) was three times what it had been 20 years before. Fruit trees (18,100,000) were down to half what they were two decades before and grape vines (302,000) were only one quarter of what they had been. It is obvious then that there is currently a great surge of active interest in ornamental planting.

In celebrating this Centennial of the Arnold Arboretum it is only fair to mention that the Arnold Arboretum has been vigorously promoting ornamental horticulture in many ways throughout its entire existence. It should not rest on its laurels.

The modern potential that arboreta and botanical gardens have in the field of ornamental horticulture is unlimited. People today have more leisure than they have ever had, and with more single homes in America than there have ever been, more gardens are being planted. More individuals are interested in flowers and trees and ornamental plants and their artistic arrangement. Consequently more individuals are looking for help

Morus alba *'Pendula'*. *Photo: Heman Howard.*

in growing and using ornamental plants than ever before. It should be a prime function of the arboreta and botanical gardens to recognize these facts and to produce better plants and better information about them so that all Americans can be active in making the world about them more beautiful.

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Harvard University

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Cold Hardiness of Woody Plants

Cold hardiness, or the capability to survive exposure to winter weather, is a major consideration in the introduction of woody plants by arboreta and botanical gardens. Hardiness is usually described in relative terms in reference to a location or a temperature. A plant is said to be hardy north to southern New Jersey, or hardy north to Boston; or hardy to 0°F or to −40°F.

How Plants Are Killed

Ice forms in almost all parts of a woody plant at temperatures more than a few degrees below the freezing point of pure water. Therefore, if a plant is to be hardy to temperatures such as −20°F, the tissues of the plant must be able to withstand the stresses caused by their freezing and thawing. A key difference between a hardy plant and a non-hardy plant is believed to be where the ice forms in freezing: inside the living cells or outside of them. If ice forms inside of cells, it is almost always fatal to them, and this is probably the principal cause of frost kill in non-hardy plants.

Normally hardy tissue may be killed by moderate temperatures that are reached by a rapid rate of freezing, e.g. 10°F per minute. These tissues would tolerate much lower temperatures under slower freezing. Here again, it is believed that ice formation inside of cells, triggered by the unusually rapid drop in temperature, is the cause of tissue death. Do such rapid temperature drops occur in nature? Under normal conditions, air temperatures usually do not drop faster than 5 to 10°F per hour. However, the rapid rate of freezing mentioned above has been measured in evergreen leaves during a sunny but very cold midwinter day when shade from a structure passes over the foliage. We believe, therefore, that damage from rapid freezing does occur in nature.

In cold hardy stems and leaves, the initial freezing of water in the tissues occurs outside rather than inside the cells, and thus the freezing is not fatal. We are not certain how cells of hardy tissue avoid internal freezing. Several factors probably are involved. Cells of hardy tissue usually have a high con-

centration of sugars and salts which lower the freezing point, and thus the relatively pure water outside of the cells is encouraged to freeze first. Once the outside freezing starts, water is withdrawn from the cells to feed the outside ice, and this withdrawal effectively concentrates the cell solution and lowers its freezing temperature even more.

Another protective characteristic of hardy cells is highly permeable cell membranes. Once the outside water freezes, the cell needs to lose water freely, and often rapidly, to the outside ice in order to maintain the cell's freezing temperature below the temperature to which it is exposed. The highly permeable membranes allow this to happen.

As water moves out of the cell, the protoplasm collapses as it does during wilting, and as this collapse progresses with lower and lower temperature, great tensions are placed on membranes and protoplasmic proteins. Since we assume that protein structures vary in different plant genotypes, species variations in resistance to these stresses might be expected, and could explain differences in degrees of hardiness.

Dr. Weiser's group at the University of Minnesota have observed an exotherm (release of heat) at the killing point of stems of fully hardened woody plants. They interpret this as being caused by the release of water which is intimately associated with protoplasmic constituents and necessary for life. The degree of hardiness of such a stem would therefore depend on the temperature at which this "vital water" is finally released.

We have indicated that stems and leaves of hardy plants can withstand freezing of water in their tissues, provided that the ice forms outside of the cells. On the other hand, hardy flower buds apparently escape injury by avoidance of freezing; once they freeze, they are killed. Apparently, buds of certain plants are able to avoid freezing down to temperatures of −30 to −40°F. How they do this remains unknown.

How Plants Develop Hardiness

Many attempts have been made to explain the development of hardiness (or acclimation) by analysis of cell constituents before, during and after acclimation. It is well known that during acclimation cells commonly lose starch and accumulate simple sugars. This was originally interpreted as a major protection mechanism. It is possible that sugars in the cell protoplasm act to reduce freezing damage to vital constituents. Sugars in the cell vacuole, where most sugars accumulate, effectively lower the freezing point of cells, but only to a limited

degree — not nearly enough to account fully for the hardiness changes that occur. Other chemical changes are known to occur in the cells associated with cold acclimation, such as changes in quantity and kinds of proteins, but these changes are difficult to translate into specific benefits to the tissues.

Cell membranes are known to become increasingly permeable to water during acclimation, thus allowing water to leave the cells more readily to feed ice crystals outside of the cells. Furthermore, reduced viscosity of cell protoplasm also occurs, probably having value in providing flexibility for surviving the stresses produced by freezing. Unfortunately, we do not know the mechanisms of these changes or how to induce them.

Investigations in recent years have revealed that plant hardiness progresses in distinct stages in response to environmental changes in the fall of the year. Hardiness does not develop until growth ceases.

The first stage of cold acclimation results from short days — a photoperiod effect. The amount or degree of hardening from short days without frost is not great compared to the ultimate hardening of stems of plants such as apple, dogwood and maple. For example, stems with an ultimate hardiness of −50°F acclimate to about O°F from exposure to short days. It has also been shown that this first stage takes place most efficiently when days are relatively warm, at least at the beginning, and when leaves are present. An especially interesting finding is that the short day effect is translocated within the plant, as if it were a naturally produced hormone.

The second stage of cold acclimation, which induces further hardiness, is caused by below-freezing temperatures. Leaves play no part in this induction, and the stimulus is not translocated in the plant.

Judging from the outward appearance of the plant, we might assume that the plant's preparation for winter is a change from an active to an inactive state. There is ample evidence, however, that many chemical and physical changes take place as dormancy and cold acclimation develop. These changes result from active metabolic adjustments, rather than the mere cessation of activity.

Root Hardiness

Two recent trends, nursery production in containers and the use of above-ground planters in landscaping, have added a new dimension to hardiness problems of woody ornamentals. Investigations into the causes of frequent winter kill of plants

in above-ground containers revealed that roots do not develop the same degree of cold hardiness as tops. Furthermore, root hardiness does not develop at the same time as top hardiness, and apparently the degree of hardiness or lack thereof can not be predicted from the characteristics of the tops.

One of the complications is that roots of woody plants do not seem to have the same type of winter dormancy as their tops. Roots continue to grow in the fall as long as the soil is above about 40°F, and apparently they will grow throughout the winter if the soil is kept warm. Since the short-day induced first stage of acclimation is translocated in the plant, one might expect that the roots would receive and respond to this hardiness induction. We do not know if this occurs, but if it does the roots must, of course, first stop growing. Exposure to freezing induces hardiness in tops (second stage of acclimation), and a similar response might be expected in roots. Our studies suggest that this does in fact occur in roots of some plants, but unfortunately not in all species. A practical method of inducing significant hardiness in roots would be a great boon to nurseries and landscaping in northern climates.

Hardiness to Winter Desiccation

For purposes of plant adaptation, we may speak of cold hardiness, when we really mean winter hardiness. An evergreen that is truly winter hardy must be both cold hardy and desiccation hardy. Winter desiccation is a major cause of leaf browning, sometimes called winter "burn", of cold hardy evergreens, especially *Ilex*, *Leucothoë* and *Rhododendron* in the climatic zones represented in Massachusetts. No matter how much water is in the soil, when the water freezes it cannot be taken up by the plant. In addition, even when water is available to the roots, if the water in the stem is frozen, no water can move through the stem to supply the leaves. At the same time, leaves exposed to winter sun and wind lose water. The combination of water loss and interruption in supply results in dehydration. Differences in the amount of injury from year to year and in different locations are due to variations in time or degree of exposure to conditions of dehydration.

Rhododendron carolinianum 'P.J.M.' is a truly winter hardy evergreen, combining remarkable desiccation hardiness with cold hardiness. We found that 'P.J.M.' could lose up to 70% of its leaf moisture and recover without injury. In comparison, *R.* 'Boule de Niege' was injured by losing about 60%, and *R. catawbiense* 'Grandiflorum' was injured by losing 50% of leaf water.

Summary

The development of cold hardiness in stems and leaves of woody plants is initiated after the cessation of growth, first by a translocatable stimulus from short days. Further cold hardiness is induced by freezing. Many of the changes that take place are probably active metabolic processes, and the changes are numerous, no one of which can adequately account for freeze-tolerance. Cold acclimation does not occur equally throughout the plant, the roots being remarkably independent from the tops in this respect. Winter hardiness, especially in evergreens, involves desiccation hardiness as well as cold hardiness.

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Plant Propagation—The Union of Art and Science

I would like to start my presentation with a word of sincere appreciation to arboreta and botantical gardens in general and the Arnold Arboretum in particular for the contributions made to the field of plant propagation. An appropriate example, during the Centennial Year celebration, is the excellent research Mr. Alfred Fordham has conducted and published in the area of seed propagation. He has contributed to our knowledge of the basis of dormancy in seed as well as practical methods by which a horticulturist can overcome seed dormancy. Plant propagation is truly the union of art and science. I would like to present a number of plant propagation techniques where this phenomenon can be exemplified.

I will continue with seed propagation. It has been known for some time that sphagnum moss improves the germination of seedlings. In part the favorable response is due to physical characteristics such as good aeration, and good moisture holding capacity. There is also apparently a fungistatic effect of sphagnum moss because damping-off usually does not occur when sphagnum moss is used as a germination medium. We were curious about the nature of the fungistatic agent and we made a number of extracts to see if we could separate it from the sphagnum moss. We found that there was in fact a substance, which could be extracted from the sphagnum moss, which prevented the growth of damping-off organisms. We also found associated with the sphagnum moss a bacterium, which when grown under culture conditions, produced a substance which inhibited the growth of organisms such as *Pythium*, and *Rhizoctonia* which can cause damping-off in young seedlings. It may be that the bacteria is the actual source of the fungistatic material associated with sphagnum moss. It is commonly recommended that the sphagnum moss should not be sterilized prior to its use because much of the fungistatic effect is lost. It could well be that the loss is due to the killing of the bacteria in the sterilization process.

I would now like to turn to the propagation of plants by cuttings in which we will see a wealth of examples in which art and science have been united to produce successful propagation techniques. When a cutting is taken from a plant, one of the primary responsibilities of the propagator is to prevent moisture loss. If the leaves are retained in a turgid condition, photosynthesis will occur leading to the production of sugars and other substances essential for root initiation which move down the stem and accumulate at the base. When a sufficient level of substances have accumulated, cell division is initiated and root differentiation follows. One of the techniques used to control water loss is to increase the relative humidity surrounding the leaves of the cuttings. The result is that the tendency of water to leave the leaf is as great as it is to enter and an equilibrium is reached. One of the first structures that was used to achieve this equilibrium was the bell jar. However, in addition to being an excellent moisture barrier, the bell jar with its restricted space also becomes a heat trap. If it is exposed to direct sunlight, the temperature will reach a point at which the plant tissues are severely damaged, if not killed. A grafting case, although more efficient in operation, uses the same principle of trapping moisture around the cuttings so as to prevent any net loss of water. Plastic tents are once again more efficient, but are based on the same principle. In each case it is necessary to provide substantial amounts of shade during sunny periods to prevent excessive accumulation of heat.

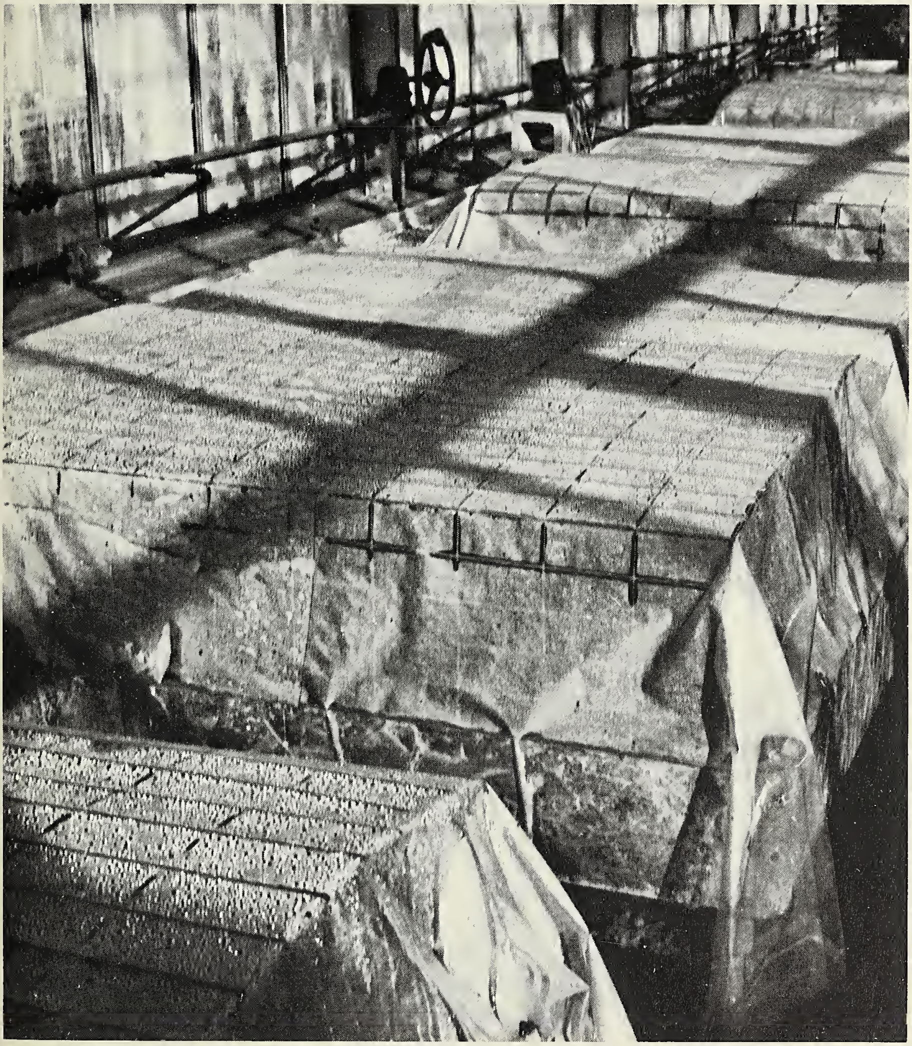
A unique variation in the use of shade to reduce the detrimental effects of direct sunlight was introduced by Mr. Guy Nearing who developed the Nearing Frame. The propagation unit consists of a cold frame covered by a reflector with an opening to the north. The cuttings receive only indirect or reflected light and therefore are not subjected to the intense heat of direct sunlight.

An alternative to building up moisture in a confined space is to use a larger structure and introduce moisture by means of a humidifier. The larger volume of air provides a greater buffer to fluctuations in temperature. However, it is still essential to provide shade for even under these conditions, the large volume of air will be heated excessively and in many cases plant tissues will be damaged.

In the early 1950's a new dimension was introduced into the control of water loss from cuttings. This was mist propagation in which a fine spray of water was applied intermittently to the cuttings. Not only was moisture introduced into the air, but

Polyethylene plastic covered propagating chambers used in autumn at the Dana Greenhouses, Arnold Arboretum. This plastic is air permeable yet vaporproof. The high relative humidity maintained reduces transpiration and prevents the cuttings from wilting. Photo: A. Fordham

as the moisture reached the leaves and then evaporated from them, it had a cooling effect. The cooler leaf temperatures reduced the rate of evaporation of water within the leaf and therefore reduced water loss. Since a confined space was no longer necessary to retain humidity, the cuttings could be propagated under open conditions and much higher light intensities could be used. As a result the cuttings were favored by greater potential rates of photosynthesis and since leaf tissue temperatures were reduced, the rate of respiration was reduced also. As a result photosynthate actually accumulated under the conditions of mist propagation whereas in conventional propa-



gation techniques, carbohydrates were used at a rate greater than their manufacture.

The ultimate in plant propagation in terms of environmental control is plant tissue culture. Under these conditions the light, moisture, and even the makeup of the nutrients on which the tissues are grown are very specifically controlled. In fact it is possible by manipulation of the media to determine whether shoots or roots, or both, are formed on the plant tissue cultures.

I would like to now consider some internal factors which effect the rooting of cuttings and one of them which has been of particular interest is juvenility. Juvenility can be expressed as the effects of the age of plants from which cuttings are taken. The younger the plants are, the greater are the percentages of rooting. It can be expressed also in the position on the stock plant from which cuttings are taken. It turns out that plants retain their juvenile characteristics in the lower portion of the plant. Therefore, if cuttings are taken from the base of the plant, the percentage of rooting is often higher than for cuttings taken from the upper portion of the plant. Propagators have taken advantage of this technique by maintaining stool beds in which the plants are constantly cut back and shoots are forced from the root system. The basal shoots have juvenile characteristics and are quite easy to root. Another alternative is to maintain the stock blocks from which cuttings are taken in the form of hedges. Again the propagator ensures that the shoots are obtained from the lower portion of the plant. An excellent example of a plant in which the effects of juvenility can be studied is *Hedera helix*. The juvenile and mature forms have distinct morphological differences. The juvenile form grows horizontally, has palmate leaves, and is used frequently as a ground cover. In contrast, the mature form grows upright as a shrub, has entire leaves, and is capable of flowering and producing fruit. The juvenile cuttings root very readily with or without a treatment with root promoting substances. In contrast, the mature cuttings root with extreme difficulty even though root promoting substances may be added. We have found that there are no substantial differences in the auxin or root promoting substances, or root inhibiting substances, in the juvenile and mature tissues. However, another group of substances which we have referred to as rooting co-factors appear to be in greater concentration in the juvenile tissues. We have developed a hypothetical scheme of adventitious root initiation shown in Figure 1 which is based on experiments conducted with the juvenile and mature forms of *Hedera helix* and other easy- and difficult-to-root cuttings. We

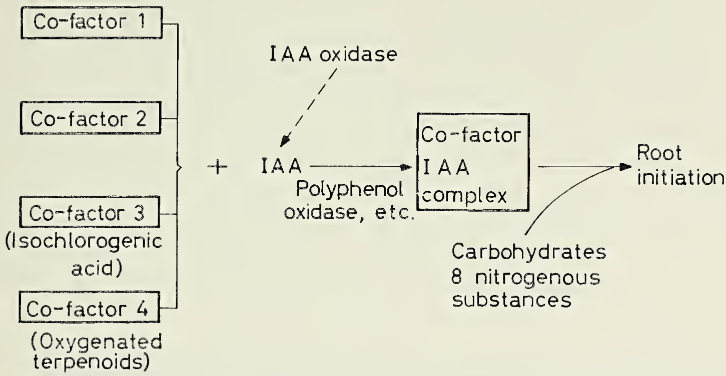


Figure 1. A hypothetical scheme of adventitious root initiation.

From: Hess, C. E. 1968. "Internal and External Factors Regulating Root Initiation" in Root Growth, *published by Butterworths, London, England.*

feel that easy-to-root cuttings contain four or more rooting co-factors and have an adequate supply of auxins. The auxin and the co-factors form a complex and if there is an adequate supply of carbohydrates and nitrogenous substances, root initiation will progress. If the cutting is difficult to root, it may be due to the lack of an auxin. This can be corrected by supplementing the auxin with a synthetic material such as indolebutyric acid, or naphthalene acetic acid. If, however, the cutting fails to root even with an auxin application, it may be due to the lack of one or more of the co-factors. In fact, the degree of difficulty can be an expression of how many and how much of the co-factors are missing. Therefore, we see that the rooting of cuttings involves the art of providing the proper environment so that cuttings will retain ample amounts of moisture and under these conditions a highly complex sequence of biochemical events can take place leading to the initiation and differentiation of root primordia.

Now let us turn to the techniques of propagation by layering. One of the factors in layering that can effect its success is the girdling of the stem prior to placing rooting media around the branch. The purpose of the girdle is to interrupt the downward movement of the root promoting substances which are synthe-

sized by the leaves and buds. As this material accumulates, just as in the cuttings, root initiation is stimulated. This phenomenon can be demonstrated by girdling the branch and then removing the shoot directly above the girdle at various time periods after the girdle was made. As the time period increases, the rooting potential of the shoot also increases. We have found that sugars, auxins, and rooting co-factors accumulate in the tissues above the girdle. Layers are usually made by mounding soil around the stem or wrapping sphagnum moss, or peat moss, around the stem and then over-wrapping it with plastic to retain moisture. The beneficial effects of the dark conditions created by the presence of the sphagnum or peat moss can be described as an etiolation or degreening effect. In many plants the initiation of roots can be inhibited if the area in which the initiation is to take place is exposed to light. This is quite in contrast with the leafy area of the cutting which should be exposed to light in order to promote photosynthesis.

Finally, I wish to discuss very briefly propagation by grafting. This is an area in which art predominates over science. Comparatively little is known about the physiology of graft union formation and what can be done to accelerate it. It is known that the botanical relationship of the graft partners must be very closely observed. It is nearly impossible to graft plants of distant botanical relationships. The phenomenon of incompatibility plays a major role in unsuccessful graft unions. Techniques such as the use of an intermediate stock, have been used to overcome the problem of incompatibility but the examples are rather few. Attempts have been made to accelerate graft union formation through the use of growth promoting and cell division

stimulating substances. Although a few instances of success have been reported, the general experience has been a lack of response. The area of propagation by grafting, therefore, is one which has great opportunities for research to provide the scientific basis to match the wealth of information that can be classified as art.

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Mist system in use for propagation at the Arnold Arboretum greenhouses. Photo: P. Bruns

Ulmus americana. *Photo: Heman Howard*

Arboreta, Genes and Plant Improvement

Under the general heading of "Arboreta and Botanical Gardens", there exists a wide diversity of institutional interests and objectives. Some institutions may be "one-man operations", while others may employ a research and teaching staff. Some may specialize in only a single group of plants, while others may maintain vast plant collections. Regardless of physical dimensions, personnel, or administrative affiliation, each and every arboretum can play a significant role in developing new and improved plant materials through hybridization and selection.

In discussing the potential of arboreta and botanical gardens in plant breeding, I will refer only to "arboreta" and deal only with woody plants. All botanical gardens and, indeed, most arboreta, grow annuals and perennials. But the improvement of these herbaceous plants is largely in the hands of commercial interests or dedicated amateurs. The realm of the professional, arboretum-oriented plant breeder is the range of woody plants — where, except for a few genera, amateurs dare not tread.

Why Plant Breeding?

There can be little argument as to the merits of scientific breeding among those plants used as food and forage. Breeding and selection of crop plants over the past century has given us high yielding, pest resistant, well adapted varieties that have, in conjunction with improved cultural practices, enabled us to reduce the acreage devoted to farming. These food plants nourish our bodies, but ornamental plants nourish our souls.

Our view of life is influenced by the view from our windows — and ornamental plants are instruments of psychological and social uplift. A recent Harris Poll, conducted for Life magazine (Hooper, 1970) was particularly revealing on this point. When a cross-section of Americans was asked to rate 26 items of "The things Americans want most", an overwhelming 95% responded affirmatively to "green grass and trees around me". Thus plants were rated ahead of churches (86%), schools (81%), and

living near close relatives (40%). This is a challenge for those of us engaged in the development, production, and maintenance of ornamental plants.

The congregation of masses of people in urban areas has stimulated attempts to restore part of the environmental heritage — trees and shrubs — in these new surroundings. But the cities are far from ideal sites for the majority of plants. Root growth is restricted by poor soil aeration resulting from soil compaction or impervious soil coverings of asphalt or concrete. Poor aeration also aggravates nutrient deficiencies and water stress. High concentrations of salts resulting from winter salting of roadways also have deleterious effects on root growth. Formerly, leaks in gas lines carrying artificially produced gas were a serious problem. Natural gas, which is becoming more widespread in use, is apparently non-toxic to plants, but may contribute to the removal of oxygen from the root environment. In addition there are subterranean wires, steam pipes, water lines, and other accoutrements and debris of civilization that further influence the environment beneath the ground.

Above ground, the city contributes its own peculiar interferences to optimum plant growth. Various air pollutants produced by industry or automobile exhausts may frequently damage the foliage of shrubs and trees or weaken their resistance to pests and climatic changes. The reflected heat from streets and buildings may also result in temperatures high enough to cause injury to plants. Overhead utility wires, while not constituting a direct hindrance to the growth of city trees, do necessitate costly tree pruning that may alter the esthetic value of the plantings.

Plant diseases and insect pests are present in both rural and urban areas, but their effects are frequently intensified by the negative influence of urban stress factors on plant vitality. Control of plant pests can usually be achieved by the use of chemicals as sprays or systemics. However, few pesticides are so selective that only a specific pest is killed or controlled. The undesirable toxic side effects of many chemical sprays have recently been emphasized in the popular literature, and while overstated in some instances, these effects cannot be dismissed lightly. Any reduction in the use of such chemicals must be considered as an ecological "plus". In the long run, the development of pest-resistant plants will provide the most efficient means of control, from both the economic and biological points of view.

In short, we are in great need of trees and shrubs that possess inherent resistance to major insect and disease pests, that can

resist or tolerate chemical air pollution, and that can survive and prosper in the man-created urban environment. In addition to their esthetic qualities, woody plants in urban settings can muffle the noise of civilization, trap particulate contaminants in the air, provide shade, and favorably alter the microclimate for man's comfort. There is also some evidence, not entirely convincing, that plants can absorb significant amounts of gaseous pollutants from the atmosphere.

However, important as these genetic goals are, they are not the only objectives for plant breeding. Suppose that one clone of Norway maple and one red-flowered azalea were the only plants that could survive in your community. As dismal as the prospects of treeless streets and a shrubless landscape might be, the use of an extremely limited range of plant materials would be tremendously dull. Novelty and variety are the spice of life, and plant breeders should strive to increase the range of variation in woody plants. A truly blue rose is asking a bit much, since the genetic material for this trait simply does not exist in the rose or in related genera. However, there are opportunities to obtain new and clearer flower and fruit colors, varying sizes, shapes, and forms, and different textures in most woody plants.

"New" plants may not be entirely new, of course, but only new to a particular geographic area. Thus cold hardiness and drought tolerance are two factors that are amenable to genetic improvement. There are obvious limitations to the movement of plants into different climatic zones, but an increased adaptability range of only 50 miles may be worth the effort.

I hope I have not belabored the need for plant breeding, but there is an urgency (in a relative time scale) for plant improvement. Ornamental plants cost money — to grow, to plant, to maintain, and to remove. With an unlimited budget, our municipal parks departments could indeed keep our cities green. The rather pathetic condition of the trees in most of our major cities is testimony to the fiscal stress of plant-related agencies. Scientific breeding of woody plants can produce shrubs and trees that will give more than a dollar's value for each dollar spent.

Why should arboreta contribute to or engage in the genetic improvement of woody plants? This question can be answered by the reason for this Symposium, the Centennial of the Arnold Arboretum. The long-term nature of genetics research with woody plants has probably been a major deterrent to the initiation and maintenance of such projects and may continue to constitute a problem in the minds of arboretum administrators. But

these administrators should recognize that they have the necessary factors, plant collections and time, to make a significant contribution in the development of genetically superior woody plants.

The time element is important. In forest-tree genetics, Libby *et al.* (1969) have stated "that between 50% to 75% of the research information potentially available from forest genetics research has been lost due to personnel changes, administrative inconsistencies, and damage due to the occurrence of some low-probability disaster". Part of this lost potential can be reclaimed by recognizing and maintaining a priority for such research projects and assigning new personnel to continue the work along established guidelines. In such a manner, the scientist will be partially repayed for this infringement on his "academic freedom" by the assurance that his own research will not be discontinued by default if he leaves.

We have seen that arboreta can exist for long periods of time. In addition, directors of arboreta generally have a long tenure. However, most directors are specialists in some nongenetic area of botany or horticulture, and must also carefully weigh the merits of allocating available land, labor, and money to the various functions of the arboretum.

Education and display are important elements of an arboretum's function, but they are local — limited to the individuals who visit the arboretum. The results of all scientific research, and especially that involving the development of superior woody plants, may extend the influence of an arboretum to national and international significance.

What is the status of plant breeding at arboreta today? Egolf (1968) surveyed a broad spectrum of horticultural and botanical institutions in the United States for breeding and selection research projects in woody ornamentals. Of the 26 organizations that reported active projects, only six could be classified as arboreta or botanical gardens. Four of these arboreta had research projects with only a single genus, one dealt with two genera, and the U.S. National Arboretum was involved with 16 genera. It would appear that the arboreta of the United States are not currently taking advantage of their opportunities in developing improved woody plants.

While I do believe that arboretum research in plant breeding is being generally neglected, I also think that this survey does not truly reflect the total involvement of arboreta in genetics research. Most arboreta, as a matter of policy, freely provide

seeds, cuttings, pollen or plants of rare species for research projects throughout the world.

The fine collection of poplars at Highland Park in Rochester, New York enabled Ernst J. Schreiner to carry out his famous poplar hybridization project in 1924. When work began in the Netherlands, in 1929, to develop elms resistant to Dutch elm disease, the Arnold Arboretum provided propagation material of five American, seven European, and five Asiatic species (Went, 1938). This spirit of cooperation in the exchange and distribution of plant materials has continued to the present day. Our relatively young, but intensive, breeding projects in shrubs (16 years) and trees (five years) at the U.S. National Arboretum have utilized the plant resources of arboreta from coast to coast and around the world.

Many arboreta are also most willing to serve as test areas for the products of breeding and selection research. The wide diversity of climatic and edaphic zones occupied by the national network of arboreta and botanical gardens make these institutions ideal as test sites. Furthermore, the plant breeder knows that his material will receive the best of care and be observed and evaluated by skilled plantsmen.

If arboreta are gene "banks", they are performing their functions of deposit and withdrawal. But the arboretum should be more than a bank. It should be a brokerage house, where the genes are invested, compounded, and diversified so that the long-term accrual of dividends can be used to stimulate the development of new projects or institutions or to tide the arboretum over during periods of stress.

In the following paragraphs, I would like to discuss some of the ways and means whereby any arboretum can get "a piece of the action" in plant breeding.

Pick A Genus

Perhaps one of the greatest deterrents to getting started in breeding woody plants is indecision with regard to what group of plants to work on. Egolf's survey listed only 31 genera currently being investigated. Without too much effort, we can easily list at least 200 genera of trees and shrubs that are items of horticultural commerce in temperate regions of the United States. There is plenty of room for involvement. The choice of genera will, of course, be influenced by the arboretum's current plant collections, the diverse interests and training of staff members, and the size, location, and budget of the institution.

The "glamour" genera, like *Rosa*, *Rhododendron*, and *Camellia*, should generally be avoided in a new project. They are well covered by commercial or amateur interests. Large genera like *Quercus* should, if chosen at all, be taken "piece-meal". But there are other genera, like *Fraxinus*, *Callicarpa*, *Hypericum*, and many more that might yield significant rewards to the plant breeder. Each arboretum should become an "area of excellence" for one or more genera, so that plant breeders at that arboretum or from sister institutions can observe, evaluate, and utilize the assembled germ plasm.

Collection of Germ Plasm

There is little I can add to the accumulated knowledge within the arboretum fraternity on "where" and "how" to obtain plant material, although it might be well to stress the utilization of the Plant Records Center and the resources of the Plant Introduction program of the U.S. Department of Agriculture. Perhaps the greatest need in most arboretum collections is for increased genetic diversity. An attempt should be made to obtain germ plasm of all species from several areas (provenances) within the species' natural range. These provenances could be selected on an elevational, latitudinal, or edaphic basis and would represent a substantial portion of the range of genetic variability available within a species. Forest-tree geneticists have taken the lead in provenance evaluation over the last 20 years, mainly with coniferous species. In hardwood genera, however, some provenance tests still involve the progeny of only a single mother-tree in each geographic zone. Arboreta, with limited planting areas, must compromise between increasing diversity within a species and adding new species. The success of plant breeding depends on the choice of parental stock, and the wider the area of selection, the more likely will be the development of improved cultivars.

The assemblage of cultivars is a special situation. A representative group of cultivars is, of course, necessary in order to measure the superiority of the products of breeding research against the plants already in the nursery trade. However, in many cases, cultivars have been selected and named more for personal reasons than for the merits of the plant. As an example, there are more than 1000 named cultivars of *Ilex opaca*, most of which, with the labels removed, could not be readily distinguished by the layman. The limited space and labor available to an arboretum could be better utilized in main-

taining different holly species or American holly cultivars from known geographic areas than in amassing all the cultivars of a single species.

Maintenance of Hybrid Germ Plasm

Plant geneticists, in addition to making controlled crosses for specific objectives, frequently engage in "reconnaissance breeding". Reconnaissance breeding is simply a broad approach to the determination of crossability patterns within a genus, regardless of the possible merits of parents or progeny. Certainly there is much basic information derived from such a venture, especially in relation to plant systematics and intrageneric relationships. However, unless some of the hybrids exhibit distinctive or superior traits, they are frequently passed over and eventually discarded.

I would argue for the maintenance of these first generation, interspecific hybrids in permanent plant collections. New pests and changing ecology are facts of life in arboreta. Who can say that some of these hybrids might not manifest resistance to a new insect or disease or prove to be tolerant to increased air pollution levels? Horticulturally undistinguished hybrids may also serve as genetic "bridges" between species that could not otherwise be combined.

There is also a warning attached to the development of new hybrids. A new hybrid combination is a "creation", and the plant breeder may feel sufficient pride in his accomplishment to select, name, and introduce the best individual of this particular progeny — even though the "best" of this group may not be as good as some other standard cultivars in the genus. The fact that a plant is a hybrid does not denote any special horticultural attributes. Only by rigorous testing and discriminating judgement can the products of scientific plant breeding become the "superplants" of tomorrow.

I have not attempted to discuss the personnel and facilities necessary for effective plant breeding research. Nor have I mentioned the extremely important mechanics of introducing a superior cultivar into the nursery trade. There are also many aspects of technical procedure that could have been explained. These topics can be saved for a later time, when more arboreta have initiated genetics projects.

What is most important is that arboreta and botanical gardens have an opportunity, and, perhaps, an obligation, to develop improved woody ornamentals. The desire to begin and the

commitment to continue a long-range plant breeding program are the only basic requirements.

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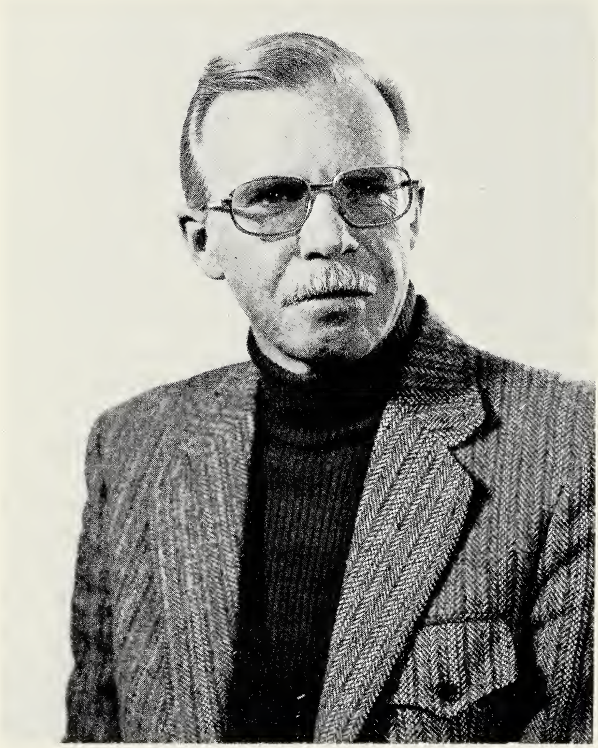

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Chromosome Cytology and Arboreta: A Marriage of Convenience

In this paper I would like to review the role cytology as a discipline, and cytologists, the practitioners of that discipline, play, or should play, in a botanical garden or arboretum. My thesis is that cytologists can play an important role in a botanical garden in fostering a better knowledge of the biology of the plants that are grown there, and in providing information of use for the breeding of new varieties, and that a botanical garden, all other things being equal, is a good place for a cytologist to be because he can benefit greatly from the use of a collection of living plants. Therefore my title: it is to the advantage of both parties to associate.

Let us start first by restricting the term cytology. Strictly speaking, cytology is the study of the cell. As a modern discipline cytology arose with the development of good quality compound microscopes in the second half of the 19th century. The great German botanist Edward Strassburger is the first outstanding cytologist, who by discovering chromosomes and karyokinesis, drew attention to the phenomena taking place in the nucleus of the cell. Soon after the rediscovery of the Mendelian laws of inheritance, W. S. Sutton drew attention to the similarity of the phenomena that occur in the cell nucleus during cell division and the predicted behavior of the genes. It was, as we all know, the American geneticist Thomas Morgan and his brilliant collaborators and students, Hermann Müller, C. B. Bridges, and Alfred H. Sturtevant, who demonstrated that indeed the chromosomes are the carriers of the genes. This led to a concentration of interest in the nucleus and the chromosomes on the side of cytologists, almost to the exclusion of every other aspect. In the classical textbook on cytology by A. J. Sharp, that dominated the scene in the United States for almost twenty years from 1932 on, two-thirds of its pages are dedicated to the nucleus and chromosomes, while C. D. Darlington's classical work, *Recent Advances in Cytology*, from about the same time is entirely concerned with chromosomes in spite of its title.

The equation of chromosome cytology with cytology comes from that time. Today the emphasis has shifted back to the cytoplasm with fantastic results as any of you who have followed the literature in cell biology knows. Nevertheless, when we speak of cytology in this paper, we are going to refer exclusively to chromosomal cytology.

Soon after chromosomes were discovered by Strassburger, it was noticed that their number was constant in the nucleus of all cells but for the nucleus of the gametes and cells of the gametophyte where it was exactly one-half. It also was soon noted that different species had different chromosome numbers in their nuclei. This fact was not let go unnoticed by taxonomists who saw the possibility of finding a constant, non-arbitrary character for use in classification. Alas, as we all know, chromosome number per se cannot provide a firm criterion of classification because related species often have the same chromosome number, and in a few cases, different populations of what on other criteria have to be considered the same species have different chromosome numbers. But the possibility that they might be the key to a non-arbitrary system of classification led to a great deal of work in the interface between cytology and taxonomy, what today is called cytotaxonomy.

I will not attempt to review the history of cytotaxonomy, but very briefly and very appropriately, point out the role that some members of the staff of the Arnold Arboretum played in the development of the field.

Although chromosomes do not provide absolutely reliable characters, as carriers of the genes, they can provide valuable information regarding the nature of the evolutionary process and the phylogeny of the species under study. Even when two species have the same number of chromosomes, they may differ in their shape and size. But even in those cases where the chromosomes are alike in their gross structure, they may differ in the internal content and arrangement of the genes. That species possess a unique individuality in their somatic chromosomes in respect to size, shape, position of centromeres and secondary constrictions and genic content was established in the 1920's by a number of workers in Russia, Europe and the United States, such as Navashin, Delaunay, Levitsky, Goodspeed, Darlington, Babcock and others. During this early period arose the concept of the karyotype, which can be defined as the phenotypic appearance of the somatic chromosomes, in contrast to their genic contents. Every species or group of closely related species has a unique karyotype, which is modified by natural

selection during the course of evolution. Consequently the more similar the karyotypes of two species, the more related they are. What are the ways a karyotype can evolve? It can evolve in a variety of ways, the most important of which are (1) change in basic number (aneuploidy); (2) duplication of all chromosomes (polyploidy); (3) change in size and (4) change in shape. During evolution one or more of these changes can and do occur, either simultaneously or consecutively, leading to the great variety of karyotypes.

One of the most unique karyotypes is that possessed by some members of the family Agavaceae, particularly the genera *Agave* and *Yucca.* These genera have five pairs of relatively large chromosomes with mostly subterminal centromeres and 25 smaller ones. This was pointed out first by J. O'Mara, Susan McKelvey and Karl Sax in 1933 (O'Mara, 1932; McKelvey and Sax, 1933) when they were on the staff of the Arnold Arboretum. At the time these genera were considered to belong to two different families: *Yucca* to the Liliaceae and *Agave* to the Amaryllidaceae. Their unique and identical karyotypes, as well as their morphological similarity, led to a reclassification of the group and the erection of the family Agavaceae by Hutchinson.

Polyploidy, that is the existence in related species of chromosome numbers that are multiples of each other, was one of the earliest cytological characteristics to be studied. An example is furnished by the genus *Triticum*, the cultivated wheat.

The earliest chromosome counts for any species of wheat are those of Overton who in 1893 reports $n = 8$ for *Triticum vulgare.* This is followed by a number of authors (Körnicke, 1896; Dudley, 1908; Nakao, 1911) all reporting the same erroneous number. The first accurate count is by Karl Sax (1918) who reports $2n = 28$ for *Triticum durum.* At about the same time, Sakamura (1918) reports the now well known polyploid series of $n = 7$ for *T. monococcum*, $n = 14$ for *T. dicoccum*, *T. durum*, *T. polonicum* and *T. turgidum*, and $n = 21$ for *T. spelta*, *T. vulgare* and *T. compactum.* Since Sakamura's paper did not contain illustrations, its results were not immediately accepted. It was Sax (1921, 1922) who in a series of very fine papers established definitely that (1) the cultivated species of wheat can be divided into three definite groups according to their sterility relationships in interspecific crosses, (2) that each of the three groups is characterized by a unique chromosome number, the three forming a polyploid series on the base of $x = 7$, and (3) classified all cultivated species into either the einkorn, emmer or vulgare group, according to their chromosome number and

crossing relationships. The discovery of the polyploid series of wheat is a very important step in the development of cytotaxonomy, since it showed clearly how cytology could aid in unravelling the phylogenetic history of a group.

Finally, an example of aneuploidy with important taxonomic implications is that of *Verbena* investigated by Haig Dermen of the cytological laboratory of the Arnold Arboretum in the 1930's. On the basis of an analysis of the chromosome number of 25 taxa of this genus, Dermen was able to establish the existence of two basic chromosome numbers: $n = 5$ and $n = 7$. He also established the existence of polyploidy within each of the two groups. Species with $n = 7$ have in general smaller flowers, the flowers are borne in spikes and they never have a glandular appendage to the anthers. Species with $n = 5$ have larger flowers, borne in cymes and often have glandular appendages. The $n = 7$ species correspond to the section Verbenaca, while $n = 5$ species belong to section Glandularia. Hybridization studies by Dermen, as well as by later authors (Schnack, 1971; Solbrig, 1968) have shown that species of different sections cannot be hybridized while species of the same section can. This and other evidence has led Schnack and Covas (1944) to erect the section Glandularia into a separate genus.

Chromosomal cytology is an invaluable addition to the arsenal of techniques and approaches at the disposal of the botanist who is interested in unravelling the past history of plants, as this very brief review hopefully has shown. We may ask ourselves, however, whether this is a valid activity for a botanical garden or arboretum. My feeling is that indeed it is. Let us see how it fits into the framework of a garden or arboretum.

The three main activities of a botanical garden can be listed as being (1) the cultivation of a large number of species of plants, both foreign and domestic, for the education and enjoyment of the public; (2) the introduction of new species and varieties of plants; and (3) research on cultivated plants and their relatives. Although many gardens restrict their activities to certain groups of plants (for example, the Arnold Arboretum restricts its activities to woody plants), every major garden comprises all three of the mentioned activities. We may then ask what kind of research should be of first priority for a botanical garden. Here it is harder to obtain complete agreement, but if we accept as a valid criterion that first priority should go to activities that will increase our understanding of the relationships of plants, in order to be able to best further a program of

introduction and cultivation, then systematics in a broad sense, including cytotaxonomy, is a valid research activity for a botanical garden. That this is a valid assumption is attested by the fact that many of the great centers of systematic activity of the world (Paris, Kew, Edinburgh, Missouri, and my own institution, Harvard) are part of, or have a botanical garden associated with it, and that most botanical gardens large and small engage in some kind of systematic research. Using the same criterion, another activity that should be placed high in the list of research priorities is plant physiology and physiological ecology, but curiously enough, research in plant physiology and physiological ecology has not been pursued by botanical gardens with the same intensity as systematic research.

If it is accepted that research in systematics is a valid activity for a botanical garden, then there is no problem in justifying cytological research, as it is widely accepted that cytotaxonomy is an integral part of modern systematics. Many arboreta and botanical gardens maintain active laboratories in cytology. The Arnold Arboretum maintained such a laboratory for some 30 years (1928–1959) under the direction of Professor Karl Sax. Kew Gardens in England has the Jodrell Laboratories with a very active cytological group under the direction of Dr. Keith Jones; in Denmark, the botanical gardens there have an active group working on cytology and cytotaxonomy under the direction of Dr. Tyge Böcher. The Botanical Gardens of the University of California started cytological work shortly after their inception in 1908, when Dr. Thomas Goodspeed joined the staff; that tradition is being maintained today by Drs. Herbert Baker and Robert Ornduff and their collaborators. These are but a few examples that show that it is valid to say that cytology should have a high priority in the research activities of botanical gardens.

But not only do cytologists aid in systematic research, they play a very important role in plant breeding. Dr. Santamour is going to refer to this phase in more detail, so I only will mention the example of the Arnold Arboretum and the extensive work on hybridization and improvement done by Karl and Holly Sax with crab apples and other members of the family Rosaceae, and with the genus *Syringa*, the lilacs, work which is documented in a long list of papers that appeared in the Journal of the Arnold Arboretum, and in the present day living collections of the Arboretum.

Having established that cytology can be of great aid in systematic research and that systematic research is a valid ac-

tivity for a botanical garden, I would like now to address myself to some of the important unanswered questions within cytology that can be best researched in a laboratory associated with a botanical garden.

The most important general area still open within chromosomal cytology is no doubt the architecture and biochemical composition of the chromosome and the events of mitosis and meiosis. Although we know a great deal regarding the gross morphology of chromosomes at one end, and we know the atomic structure of DNA, we know very little regarding the fine structure of the chromosome. The ordinary electron microscope has been of no help in this respect, but the scanning electron microscope and the imaginative use of physico-chemical and biochemical techniques may still succeed in unravelling the secrets of the chromosome. Although the question of the nature of the chromosome and the events of mitosis and meiosis is the most important unanswered question in the field of chromosome cytology, it is not one that should have first priority in a laboratory associated with a botanical garden or arboretum. The reason that I feel so is that it is a kind of research that does not require nor takes advantage of the richness and diversity of the living collection, while on the other hand, making great demands of resources and expertise in electron microscopy, biochemistry and biophysics which are not likely to be found in a botanical garden. So the answering of this question and similar ones are best left to a university or governmental laboratory. The kind of cytological research that can be best pursued in a botanical garden or arboretum is that which takes advantage of the diversity of plant collections that exist in a botanical garden. What are some of these activities?

First there is still a great deal of routine inventorying of chromosome numbers to be done. At present we have established the chromosome number of only approximately ten percent of all vascular plants. Furthermore, while our knowledge is fairly good for certain groups, such as ferns and Compositae, it is almost nonexistent in other groups. But routine surveys, although useful, are not the most efficient way of acquiring knowledge, nor the most imaginative way of spending one's time. Whenever possible, such surveys should be done in conjunction with systematic investigations, in order to be able to interpret the meaning of the results in an evolutionary framework. Furthermore, such investigations, whenever possible, should not be restricted to chromosome number alone but should include investigations of other aspects of the karyotype as well. A good

example of what can be done is furnished by the collaborative activity of my associate, Mrs. Lily Rüdenberg, and Mr. Peter Green, a former staff member of the Arnold Arboretum, in their work on the genus *Lonicera.*

The Arnold Arboretum possesses an unusually rich collection of species and varieties of *Lonicera.* The genus was monographed by Alfred Rehder, who was head curator of the herbarium of the Arnold Arboretum for many years. Rehder worked with the collection of *Lonicera* and was responsible for many of its identifications. The collection is therefore not only unusually rich in taxa, but they are in excellent taxonomic order. Mrs. Rüdenberg with the taxonomic assistance of Mr. Green systematically established the chromosome number for every growing shrub in the collection, a total of over 100 taxa. She established that the basic chromosome number in the genus is nine, and that the majority of species are diploid. They also established that many of the varieties and cultivars of diploid species are tetraploid. Mrs. Rüdenberg was also able to establish that the chromosomes of *Lonicera* have interesting heterochromatic areas, a phenomenon which she is still investigating.

Once enough information has been gathered from a routine survey, a number of interesting higher-level questions appear which I feel are one of the most challenging areas to be investigated. Let me illustrate this point with an example.

Almost fifteen years ago, Dr. Peter Raven and I decided to initiate a survey of the chromosome numbers of the family Compositae. In this enterprise we were joined by a number of colleagues, and in the intervening years we have published over one thousand counts, including first counts for many species and genera (Raven et al., 1960; Raven and Kyhos, 1961; Ornduff et al., 1963; Payne, Raven and Kyhos, 1964; Solbrig et al., 1964; Ornduff et al., 1967; Solbrig et al., 1969, 1972).

As a result of our work, and a similar parallel survey being undertaken by Dr. B. L. Turner and collaborators, as well as many other reports in the literature, approximately 25 percent of all species in this large family of flowering plants have been counted. Figure 1 shows a summary of the results obtained to date. Several aspects are revealed in the figure. First we see that the chromosome numbers in the Compositae are not randomly distributed but that they follow a very definite pattern, with a mode of nine and a more or less lognormal distribution. From this we concluded that nine is probably the ancestral chromosome number, although this of course is only a probability statement inferred from the evidence at hand. But there are

Figs. 1 and 2: Frequency of species with different chromosome numbers by habit in Compositae and Leguminosae, respectively.

other interesting observations that can be made. A very significant one is the correlation between habit and chromosome number. For the family as a whole as well as within each tribe, annual herbs have as a group a lower chromosome number than perennial herbs, which in turn have a lower chromosome number than shrubs or trees, although the sample number for this latter category is so low as to render this statement statistically suspect for the family Compositae. Finally the distribution of chromosome numbers is not uniform throughout the family, but certain tribes such as Cichorieae and Astereae have more species with lower chromosome numbers as well as lower numbers in an absolute sense ($n = 2$ for Astereae, $n = 3$ for Cichorieae) than Heliantheae ($n = 5$). From this information a number of interesting questions arise, such as the following: (1) Why do annual herbs have a lower chromosome number than shrubs and trees? (2) Why do different tribes have a different distribution of chromosome numbers? (3) What is the significance of a "basic" chromosome number? The answers to these and similar questions are among the still unresolved aspects of cytotaxonomy. They involve the role of chromosomes as regulators of recombination, and the past history and geographical distribution of the various tribes (Solbrig, et al, 1964; Solbrig, 1972).

We can go a step further and compare the Compositae with other families. I have made such a comparison with the published chromosome numbers for the family Leguminosae (Solbrig, 1972). Figure 2 shows the distribution of chromosome numbers in that family. We can see that in this entirely unrelated family we again observe that annual plants as a group have lower chromosome numbers than perennial herbs, which in turn have lower numbers than shrubs and trees. This leads me to believe that we are dealing with a phenomenon that is general to the plant kingdom. The explanation of the reason of the correlation between habit and chromosome number is to be found in the functioning of the recombination system. Annual plants have of course shorter generation times and consequently a higher recombination index, all other things being equal, than populations of species with longer generations. A way to compensate for this higher rate of recombination is to increase genetic linkage by lowering the number of chromosomes. Although this explanation is highly plausible (Grant, 1958; Solbrig, 1972), more experimental and observational evidence is still needed.

Another observation that can be made from Figure 2 is that the modal chromosome number of Leguminosae and Com-

positae is different, as well as the distribution of numbers in the two families, although the general form of the curve is similar. So far this difference has been attributed always to a more or less mythical "phylogenetic component", but that non-explanation is to me very unsatisfying. I believe that as more information is accumulated for more families, more satisfying hypotheses based on firm foundations taken from genetical, ecological and evolutionary theory will be forthcoming. This is one of the still unresolved areas, and one which is very appropriate for a cytological laboratory connected with a botanical garden or arboretum to pursue. Only where a great variety of plants grow can this work be undertaken.

In summary, then, chromosome cytology and botanical gardens are a marriage of convenience. For the institution the existence of a cytological laboratory will ensure that active research will be done with the collection, research that is interesting in itself and significant and of general interest in terms of botanical science as a whole. Furthermore, it is research which has direct bearing on systematics and plant breeding, two aspects that are very central to the research activities of any botanical garden or arboretum. For the cytologist, the existence of living plants that can be monitored and studied throughout the year, as well as the presence of representatives of many genera and families, and the possibility of cultivating under expert care those organisms that are of particular interest to the researcher offer unique possibilities, with which most of us dream, but seldom see realized. The cytological laboratory of the Arnold Arboretum, which has counted over the years such outstanding researchers as Karl and Holly Sax, Edgar Anderson, Dermen and more recently, Joab Thomas, and their numerous students like Carl Swanson, Allan Conger, and Arnold Sparrow to name just a few, is a fine example of the role a cytological laboratory can play in a botanical garden. We wish it an equal or greater success in its second century.

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Horticultural Education—Participants Warmly Invited

To me, the last three words of the title suggest a pleasant association between individuals with the bond of a special interest or in the pursuit of a common idea. Our bond of special interest is horticultural education and botanic gardens and arboreta.

Asking questions seemed to be the easiest way to present my material. More questions are raised than are answered. The questions apply to many botanic gardens and arboreta; the answers must come from the individual institutions. Local circumstances will determine the answers more often than not. For instance, in the matter of financial support, there are three types of botanic gardens or arboreta. Those operating entirely on private funds; those receiving some public money; and those wholly supported by public money. This factor, alone, is cause for different responses to a common question.

No accounting will be made of the current ways gardens and arboreta educate people in horticulture and botany. Such listings are available from every institution. It must be acknowledged that the offerings, both formal and informal, are extensive and of an amazing diversity.

It is my intention to consider what more we might try to do, as we move along through the 1970's, the '80's, and the '90's.

There are three groups of Participants whose future will be considered: the Public, the Staff, and the Policy Makers.

We will begin with the Public, because *IT* is so easy to identify. *IT* is everyone outside the Staff. *IT* is seen on the grounds every day. *IT* fills our educational classes. In fact, we have become so accustomed to the Public's presence, we often refer to this group with a singular implication.

Maybe, it is time we looked at this Public more closely. If the composition is not as stable as we assume, is this reflected in our educational plans for the future? Are our plans flexible enough for frequent changes?

A recent population survey of 70 major cities, including New York, revealed that the average residence in one place is less

than four years. Reviewing the 885,000 telephone listings of Washington, D.C. for 1969, it was found that one-half of this number was different from the year before, 1968. Think for a moment about the thousands of air travelers who fly the length and breadth of this country daily. For many, the flight is a transfer from one city to another. Add buses, trains, boats and the family car to this transportation fleet, and we begin to realize what a mobile people our society has become. It's more than likely that you know people who have changed their job and location more than once in the past ten years. If the social and economic survey makers are at all correct, their predictions are, "that we ain't seen nothin' yet" in the moving about of the American family.

How aware are botanic gardens and arboreta of this phenomenon of Public mobility? Might the old neighborhood be changing?

"Gardening Methods in This State for the New Resident". Is there such a course offered anywhere? Which gardens or arboreta have a printed leaflet which identifies local ornamentals for the visitor from out of state? Who has a booklet designed for the hitch-hiking/camping youth movement, becoming increasingly noticeable on our highways? Couldn't we make their travels safer and more pleasant by illustrated guides to poisonous and edible plants? Or make them aware of the different ecological zones they invariably pass through? How much training is being offered young men and women in geographically oriented horticulture and botany? Today there is every likelihood that these young people will seek jobs hundreds of miles away from the site of their training or apprenticeship.

Isn't it a responsibility of ours to maintain a constant awareness of our changing times and increase our effectiveness toward Participants Warmly Invited for our mobile Society?

There's yet another point of reference concerning the Public.

How many gardens or arboreta still use the premise of the homeowner, living in a single family unit, surrounded by a yard as a basis for planning education programs? Is it time that this premise be broadened?

For instance, as the "urban Edsels", those high rise apartments and office buildings mushroom, are we offering sufficient instruction about house plants and their culture? Where is there a course teaching gardening on a 4 x 10 foot concrete patio, perched on the side of a building 30 stories above the ground? For that matter, what do we ourselves know about the micro-

climates surrounding such living quarters? How many courses are there about the use of artificial light in plant culture? Should we be teaching apartment dwellers how to grow vegetables on their building's rooftop? Is it time to bring back some form of soilless gardening? Should we even be concerned about this Public and their relationships with plants or plants with them? I think we should be, but how do we implement a Participants Warmly Invited message for these people?

A word about environments and ecology before we leave this no-yard Public.

In most cases, there is a park, a planted parkway, a flower shop, a supermarket and weeds in vacant lots within walking distance of our apartment Public. There are also rain, sun, snow, shadow, wind, carbon monoxide, carbon dioxide, sulfur fumes, some oxygen, and plain dirt in the air. Isn't there some way that a city-related botanic garden or arboretum could develop a subject program that would weave all these natural and man made elements into a meaningful, educational experience of horticulture or botany for these city dwellers? Truly, we need more Dick Howards and his "Botany in a Grocery Store"!

The Public also inhabits an area currently classified as the "inner city". Does anyone remember what these areas were called before this term became so popular? Anyhow, there is a real horticultural wasteland.

Not too long ago, I held a strong conviction that very little could be done to rehabilitate these areas of shambles of people and property. Have you ever visited one of these areas? The sight chills the mind; the renewal problem staggers the imagination. Happily, attempts are being made to lessen the blight. Three such examples have given my thinking a new direction and hope.

Mrs. Louise Bush-Brown led the way. By encouraging the use of plants in a very simple manner, she sparked the gradual development of a whole new neighborhood atmosphere, inside and outside the houses, in an otherwise disaster area of Philadelphia. The financing required was minimal. Read the story in her book, *Garden Blocks for Urban America.*

Charles Lewis, Director of Sterling Forest Garden, Tuxedo, New York, was second. As a volunteer, working with the New York City Housing Authority, he has helped direct a beautification program of some 5,000 low-income apartment tenants. This program is a summer garden contest of about ten years' duration. Unsolicited comments by participants to Mr. Lewis,

attest to the facts that vandalism was reduced, an improvement in tenant relationships has occurred, and that litter accumulation has declined in the contest-involved apartment areas.

The Raymond School, located in a depressed section of South Chicago, now has a combined school yard garden and a nature trail area one block long. Three years ago, that school yard was almost indistinguishable from the paved street outside the fence. The Morton Arboretum and a woman volunteer from the Chicago Horticultural Society assisted a bright, young biology teacher and the students of the whole school to bring about this transformation.

These are not high caliber horticultural nor esoteric botanical exercises, but they did have Participants Warmly Invited, plants were the first consideration, and four AABGA members were involved. Is it not possible for every botanic garden and arboretum to find funds and people to effect one such betterment in the quality of life in their community?

A sampling of active AABGA members from Coast to Coast was asked to state what they believed to be the most important consideration in planning for the future of horticultural education and botanic gardens. Two suggestions occurred repeatedly in their responses.

First, botanic gardens and arboreta must provide more extension type services. These extension services must be directed more and more toward children and young adults. Trips to the garden or arboretum are important, but to influence these young people more successfully we must go to their home grounds. There are libraries on wheels, summer performing arts in mobile vans, and mobile historical exhibits. Has any garden or arboretum tried putting horticulture or botany on wheels?

The second suggestion was by far the more important. We must do more interpretive type instruction in horticulture and botany.

Reading through class announcements of many botanic gardens and arboreta, it is seen that the "how to" approach to subjects predominates. The "why" appears in few titles. If we listen, even with half an ear, to today's self-titled "under 30" young people, the main thrust of their concern about our and their society is trying to find the "why" in the system. For horticulture and botany, shouldn't we supply more of the "why" in the relationship between man and plants? Anyone who has read the book by Mrs. May Watts, *Reading the Landscape*, or has attended one of her lectures on the subject, realizes she is saying something quite different from just "looking at the landscape".

Facts and correct skills are important; however, it's only through understanding how these two fit together that we are to make progress toward saving, if not improving our environment for the future.

Our second Participant group is the Staff.

One of the most important endowments an institution can accumulate is a knowledgeable and alert Staff. After all, it is the Staff that makes possible the attainment of the goals we set. To what extent should Participants Warmly Invited involve the Staff?

Does any arboretum or botanic garden include in their recruitment statements, "on the job training with pay", or "continuing educational opportunities with pay"? Such offerings are found in ads for other professions and private industry today. Other than through seniority, do we provide in-house training, leading to promotion from gardener-helper to garden foreman, to superintendent?

Someone will think or say that we already offer higher entry salaries, more fringe benefits, more overtime and longer vacations than any time in the past. In many cases this is true, and that's the point. Today, with his physical needs fairly satisfied, the employee seeks the meaning of his job and its relationship to the whole process. This is no less so in an arboretum or botanic garden than it is in Ohio where it is reported that 100 cars a day are made at one automobile plant.

If one feels there has to be more of a balance of payment to the institution by the employee for his gains in benefits, wouldn't a Participants Warmly Invited program be of value to the administration in terms of increased productivity?

Why shouldn't formal sessions be held regularly to improve or update Staff skills? An opportunity should be provided to explore and answer the "what", "why" and "how" of each job considered.

Shouldn't we carry on a continuous program of management training and procedures for the various levels of Staff responsibilities?

Wouldn't our institutions benefit by encouraging our Staff to be active in a recognized society concerned with their skill or profession?

Do we have enough "Staff meet Staff" exchanges? If the greenhouse foreman knew why the research man gets so "up tight" about watering, shading or container labels, he might give more consideration to the care of these special plantings.

It is said that travel is educational. How many of our Staff do we insist or assist to visit other botanic gardens or aboreta to learn new methods or bring back new ideas?

How far down the Staff line do we go in our planning sessions? Do we include those who really will carry out our plans?

Staff education or Participants Warmly Invited must include every level and every individual of the Staff to be entirely effective.

Now we come to the last Participant group, The Policy Makers — Trustees and government agency members. Their inherent authority and responsibilities, alone, signal this group's importance to botanic gardens and arboreta. There are many ways to play the game with the Policy Makers. But if our institutions are interested in reaching their goals more quickly and more surely, there is only one way to positive results — involve this group in Participants Warmly Invited programs as completely as we should the Public and the Staff.

What do all Policy Makers have in common which affect a garden or arboretum?

They are interested:

— In our actual programs and services
— In the long-range plans of development
— That we improve the life quality of the community
— That the sources of financial support are satisfied with our progress,

and they receive:

— Personal recognition for helping to guide successful gardens or arboreta
— Pride, and a sense of honor being associated with our type of cultural endeavor or scientific professionalism.

So much for how Policy Makers view us. How or what should be our view of them? Or, we might ask, what director can operate successfully today without the Policy Makers':

— Strong community leadership
— Political clout
— Financial clout
— Real ability to make things happen or not happen
— Personal, private associations which often, like a giant web, reach far beyond the immediate vicinity of the botanic garden or arboretum.

Since the Policy Makers do make decisions which directly affect our daily operations, shouldn't we make certain that we

furnish them the best possible professional information and advice within our capabilities?

Public supported institutions are being asked increasingly for accountability in the use of tax funds. What greater satisfaction can we experience than to have a well informed Trustee step up to the Hearing Room's microphone and speak meaningfully in our behalf?

Suspicion always runs high in the minds of government people and some Trustees that a director's budget request is unreasonably padded. If we accept this appraisal without making every effort to make these people Participants Warmly Invited, are we not more at fault than the Policy Makers?

It's a fact of life, many of us need every penny of all the funds we receive. Can we not find the time and the way to more thoroughly educate the Policy Makers?

What does it really cost to put the government agency's key budget or planning people on our mailing lists for all materials sent to our members, the press or the general public?

Should not Policy Makers participate in the early stages for planning requests? Policy Makers (particularly when local politics are involved), familiar with our needs and intent, have been known to give sound advice on how and when to submit requests in order that they will receive the best possible consideration.

In one sense, the Policy Makers are the Public, too. Aren't they outside the Staff? Why not invite them to every horticultural and botanical function offered the general public? Policy Makers own homes, work in their yards, buy house plants, and enjoy pleasing landscapes. Some, even, are very active in one or another of our plant societies or garden clubs.

One of the most productive Participants Warmly Invited programs for this third group is a planned visit to the garden or the arboretum. Why not, once or twice a year, provide an "insider's" view of your operation for the Policy Makers? Not just a walk through with the Director and other top brass. This should be an occasion for "show and tell", in which every Staff member demonstrates his/her contribution to the daily operation of the garden. Trustees have many opportunities at this time to show their accomplishments, too. The government members not only see what they have helped provide, but find out how concerned and dedicated we are about horticulture and botany. By the way, don't forget to have a lunch or dinner planned for this outing, and be sure to invite the wives!

My present concept of Participants Warmly Invited needs only a few summary statements.

The ascendency in the magnitude of mobility for some, and the complete inability to move by others, is rapidly segregating our once stable Public. Arboreta and botanic gardens must be continually aware of the changing times and reappraise what they offer in horticultural and botanical education.

Today the life styles of our Public are changing, too. Space is vertical, open surfaces are hardened, interior space is air-conditioned; yet, we continue to offer classical and conventional courses in horticulture and botany. Arboreta and botanic gardens must adapt the usual to the unusual in the plant cultural situations now developing within their communities.

We, ourselves, would probably agree that the excitement of this life is finding out the why of living things. Arboreta and botanic gardens continue strong in teaching the how and what of plant culture. The insurance of future healthy environments depends on higher premiums paid to interpretive instructions.

Human, basic needs are reasonably provided for, even in the jobs of horticulture. The employee seeks the meaning of his work to a degree far greater than his father or grandfather did in their day. Arboreta and botanic gardens must adopt management procedures which meet this need through in-house educational programs.

Because of growing economic and social pressure from outside our fences, the role of knowledgeable and willing Policy Makers is assuming ever-increasing importance to us. Arboreta and botanic gardens must develop a better understanding of goals and purposes between themselves and their sources of community support and influence.

Dr. William Steere recently put it this way, "Today, man is rapidly coming to the realization that his activities — burgeoning population and runaway technology — are drastically changing environments. The reality of man's relationship to the biological world, needs the widest communication possible."

What better or more natural way can arboreta or botanic gardens find to continue their leadership in responsible horticultural and botanical education than through a consciousness of

changes in the community and a program of Participants Warmly Invited which adapts to these changes?

Louis B. Martin
President
Chicago Horticultural Society

Sir Joseph D. Hooker

The Role of Lower Plants in the Research Programs in Arboreta and Botanical Gardens

When I first prepared a draft of this paper late in 1971, after Professor Howard had invited a contribution, I was of the opinion that lower plants, interpreted here as non-vascular plants, had no other significance in the arboretum or botanical garden than as highly suitable material for research. However, after a second visit to the Higashiyama Botanical Garden in Nagoya, Japan, in early April, 1972, I have had to modify this view, as in a spectacular exhibit of interesting ground covers were included, as well as several orchids, two mosses (a species each of *Leucobryum* and *Rhodobryum*), which apparently flourish in the moist climate of oceanic Japan. Of course, moss gardens are traditional in Japan; the most impressive is the Kokedera in Kyoto.

Botanical gardens conducted primarily for botanical purposes were a product of the European Renaissance, and were closely related to a university or some other institution. The earliest gardens of this type were found in Italy during the sixteenth century, and the movement spread northward into France, Germany, Holland and England during the seventeenth century. Because of the broad intellectual spectrum of the universities, it was not considered unusual or anomalous to include the study of cryptogamic plants in the botanical gardens associated with them. Also, once botanical gardens began the sponsorship of collectors in other and richer botanical areas of the world, or the sending out of full-fledged expeditions, many plants other than vascular plants had to be identified and curated, either in the garden or the herbarium. Moreover, it is only natural that the administrative officers of a botanical garden or arboretum should be concerned with actual or potential diseases of the plants they are cultivating, so that the association of mycologists and plant pathologists with such botanical institutions became customary soon after the disease-producing capacity of bacteria and fungi was discovered.

By definition, an arboretum is more specialized than a botanical garden, which, by its own definition, in turn, is free to consider all kinds of plants, in addition to woody ones, as objects for display to the public, for instruction, or for research purposes — or for all. To my knowledge, cryptogamic botany has rarely been considered as an appropriate adjunct to an arboretum, except perhaps in its wholly practical aspects, with reference to plant diseases, as already noted. In most of the great botanical gardens of the world, however, cryptogamic plants have received almost better attention than in other botanical institutions.

I have divided this paper into two parts, first, a cursory historical review, and second, a review of the situation today, plus a tabular summary derived from two relatively modern sources, *International Directory of Botanical Gardens II* (1969) and *Index Herbariorum*. Part I. The herbaria of the world (Fifth edition, 1964).

Historical Review

For a brief historical review, on a "for example" basis, I shall begin with the New York Botanical Garden, simply because it is the institution I know best.

Cryptogamic botany has been represented at the New York Botanical Garden from its very beginnings, in close association with Columbia University. Elizabeth Gertrude Knight Britton, wife of the founder and first director, was a bryologist of great talent who built up the bryological collections in the herbarium of the New York Botanical Garden and carried on productive research in mosses. Robert Statham Williams joined the staff of the Botanical Garden in 1899 and became a highly distinguished bryologist. Marshall Avery Howe, who joined the staff of the Garden around the turn of the century, had written his thesis at the University of California on the Hepaticae of that state, then turned his hand to the marine algae, especially of tropical areas, once he moved to New York. Lucien M. Underwood, a distinguished specialist on ferns, spent many years at the New York Botanical Garden. From the very beginning a mycologist has been in residence; Dr. Clark Rogerson and Dr. Kent Dumont today represent their several illustrious predecessors. The field of plant pathology has also been represented continuously during the present century at the New York Botanical Garden, and the brilliant work of Dr. B. O. Dodge on *Neurospora* led subsequently to several Nobel prizes. As a result of the involvement of cryptogamic botanists in the scientific work of the

Elizabeth Gertrude Britton. Photograph taken at her desk at The New York Botanical Garden, June 22, 1902.

Lucien Marcus Underwood on Blue Mountains in Jamaica.
Photo: A. Rehder, 1903.

Botanical Garden from the very beginning, the collections have grown steadily; also, in the early days many important private collections were purchased which are now invaluable because of their large proportion of type specimens.

This surprising abundance of cryptogamic botanists at the New York Botanical Garden had several causes. As already mentioned, Mrs. Britton was a prominent bryologist, and undoubtedly had considerable influence on her husband's interest. Moreover, Dr. Britton had a very broad scope of interest — after all he himself had started out as a geologist — and his concept of the Garden was very broad. Finally, with so many botanists of all kinds working in the tropics in new areas, it was necessary to have different specialists to handle the large amounts of the several groups of plants that were collected and brought back to New York. I have used the New York Botanical Garden as my first example, not because of vested interest, but simply because of all American institutions it has had the widest scope of cryptogamic botanists in the country over a long period, and still maintains broad representation in these fields.

The Missouri Botanical Garden has emphasized its work on higher plants, so that cryptogamic botany has never become very well developed as a broad field. However, there has always been some one specialist in cryptogamic botany in residence, and at the moment the cryptogamic botanist is a bryologist. The Brooklyn Botanic Garden has placed its emphasis almost totally on higher plants, cultivated ones as well as native plants, almost to the exclusion of cryptogams. Dr. Paul Burkholder, one of the few exceptions, was considered an algologist largely because he used this group of plants in his physiological experiments, although he did not concern himself with developing a collection either of herbarium specimens or of living cultures on a broad representational basis.

At Kew, Sir William Hooker and Sir Joseph Hooker, father and son, were both accomplished cryptogamic botanists, with a special interest in bryophytes, in addition to their even greater brilliance in higher plants, so that, as directors of Kew, they encouraged the development of bryological collections. However, since the Hookers, bryological research at Kew has been desultory and the collections have lain fallow. The same situation seems to be true of the fungus collections. In fact, for decades there has been talk, sometimes serious and sometimes not so serious, of turning over the collections of lower cryptogams to the British Museum (Natural History), and this may now have been done with the fungi, in exchange for herbarium specimens

of higher plants of greater interest at Kew. I should hasten to say, however, that the collections of ferns and their relatives at Kew are outstanding, both ferns growing in the great fern collection and in the herbarium, thanks to a series of specialists in this group. I am sure that the ferns will continue in ascendency at Kew.

At the Komarov Botanical Garden and Botanical Institute at Leningrad cryptogamic botany has perhaps reached a higher level of development than in any other botanical garden around the world, unless we except the early days of the New York Botanical Garden. There are productive workers in the field of freshwater and marine algae, in many groups of fungi, and in bryophytes. In many ways, this is the most influential botanical center in Russia.

The Royal Botanical Garden at Berlin-Dahlem has long been a great center of bryological research, as well as in other groups of cryptogams, especially lichens and fungi. The bombing of Berlin during World War II destroyed many of the cryptogamic collections, however, and most type specimens of Carl Müller especially do not seem to be any longer in existence, although many of the higher plants had been put into safekeeping for the duration of the war.

Most other major botanical gardens in Europe have a long history of involvement with lower cryptogams, of which the University Botanical Garden and Institute in Copenhagen, and the Royal Botanical Garden in Brussels deserve special mention.

To repeat, the emphasis on the taxonomy and geographical distribution of lower plants has been as great, if not greater, in major botanical gardens as in other kinds of botanical institutions.

The Modern Situation

Major botanical gardens are still following their ancient tradition of using lower plants as research material, even though today much of the work tends to be more experimental and less descriptive. The classical experimental work by Dr. B. O. Dodge on *Neurospora* has already been mentioned. Also at the New York Botanical Garden, an important research program is directed to the biochemistry of natural products of fleshy fungi, and to the sex hormones of water molds. Other botanical gardens throughout the world are carrying on similar research programs. The deep concern of many people for the improvement of environmental conditions is reflected in the botanical gardens that are developing special races of plants that may serve as

indicators of air pollution, for example. Mosses and lichens have been discovered to be excellent indicators of air pollution, in both negative and positive ways. In a negative way, most lichens and mosses that normally grow on tree trunks several feet above the ground are very sensitive to air pollution, especially to sulfur dioxide, so that there is an almost perfect correlation between the increasing concentration of SO_2 and the decreasing number of plants of bark-inhabiting lichens and mosses. On the other hand, some few mosses and lichens seem to be able to metabolize SO_2, and are therefore able to survive or even thrive in a polluted atmosphere. Their presence alone gives positive evidence of air pollutants, just as the absence of species that do not tolerate pollutants gives evidence of a more negative nature. A good deal of information can be obtained from the herbarium on the increase in air pollution by early collections of indicator species in areas where they no longer can survive. The use of lower plants as indicators of other environmental factors, such as moisture, humidity, rainfall, pH, etc., makes them useful tools for ecological research in botanical gardens.

In early times, the nature of botanical gardens and arboreta was simple — they either did or did not include lower plants in their research programs. Today the situation is so complex that unravelling the administrative structure has become the key to answering the question. Although the administration of botanical gardens and arboreta is a perennial topic of conversation among the staff members thereof, I do not know of any scholarly or comparative study of administrative structure on a historical or evolutionary basis. However, I do detect one trend that you may recognize also from your own experience, namely, the development of the botanical institute through the gradual separation of the herbarium function from the botanical garden and arboretum function, and the separation of both of these from the teaching function. I might cite, as an example of this trend, the situation in Montreal, where the Institut Botanique of the University of Montreal and the Jardin Botanique de Montréal share the same building, carry on somewhat overlapping herbarium activities yet whose staffs at some times in the past were really not on close terms. At the University of Michigan, the Botanical Garden is closely affiliated with the Department of Botany, whereas the herbarium is a separate department of the Literary College. In other institutions, at the other end of the spectrum, there may be no administrative separation of teaching, living plants and herbarium.

In combing through *International Directory of Botanical Gardens* II (1969) and *Index Herbariorum* (Part I, Fifth edition, 1964), for the background information to establish the modern situation, I encountered many ambiguous entries. As a result, although I have tried to quantify the data extracted from these two publications in tabular form, there still remains a strong qualitative element, based on my own judgment in the interpretation of entries (Table 1). My error in interpreting the entry as a botanical research institute, separate from the botanical garden, may have resulted in the omission of important institutions. Also, my adherence to these two publications as my source of information means that the data summarized here are already out of date. I could have corrected and up-dated the entries for several institutions that I know personally, yet this treatment would have been unfair to those institutions unfamiliar to me. To give consistency to my data base, I have adhered firmly to the information gleaned from two publications, while recognizing fully the error built into the use of data that may be up to ten years old. (See Table 1.)

William Campbell Steere
President,
New York Botanical Garden

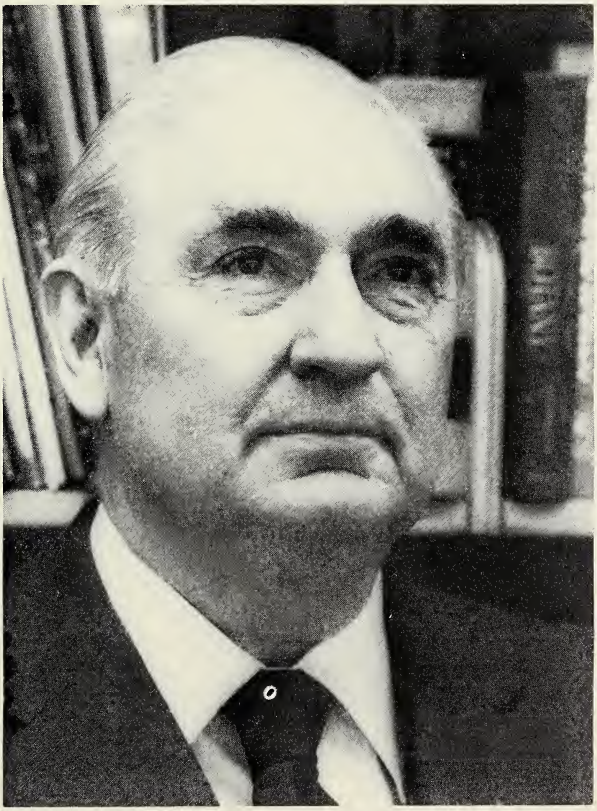

TABLE 1. List of Botanical Gardens and Arboreta showing numbers of staff members whose primary research interest is in non-vascular plants or in plant pathology. Derived largely from *International Directory of Botanical Gardens II* (1969), with supplementary information from *Index Herbariorum.* Part I. Fifth Edition (1964)]

	NUMBERS OF STAFF MEMBERS					
COUNTRY AND NAME OF INSTITUTION(S)	ALGAE	FUNGI	LICHENS	BRYOPHYTES	PATHOLOGY*	ALL OTHER FIELDS
Australia						
Royal Botanic Gardens, Sydney	1					12
Belgium						
Jardin Botanique National, Brussels	1	1		1		4
Brazil						
Jardin Botânico de São Paulo	3	4	1	1		27
Canada						
Botanic Garden & Arboreta, Ottawa		2				11
Denmark						
Botanic Garden of University, Copenhagen	1	1	1	1		6
Egypt						
Botanic Garden Univ. Alexandria	1	1				3
France						
Station de Botanique et de Pathologie Végétale, Antibes		1			2	5
Jardin Botanique de l'Ecole Nationale Supérieure Agronomique, Grignon		1			2	1
Jardin Botanique Strasbourg					1	3
Germany						
Institut für Spezielle Botanik und Arboretum, Humboldt Univ. Berlin				1		6
Botanischer Garten und Botanisches Museum, Berlin-Dahlm	1		1	1		11
Staatsinstitut für						

(Table 1 *continued*)

COUNTRY AND NAME OF INSTITUTION(S)	NUMBERS OF STAFF MEMBERS: ALGAE	EUNGI	LICHENS	BRYOPHYTES	PATHOLOGY *	ALL OTHER FIELDS
Germany (continued)						
Allgemeine Botanik und Botanischer Garten, Hamburg	1	1	1	1		7
Botanischer Garten, Univ. Rostock				1		3
India						
National Botanic Garden, Lucknow		1			2	19
Indonesia						
Kebun Raya, Bogor	2				1	4
Italy						
Orto Botanico, Univ. Camerino				1		2
Istituto ed Orto Botanico, Napolí	1					2
Orto Botanico, Univ. Padova	1	1				4
Istituto ed Orto Botanico, Parma					1	3
Istituto Botanico Univ. Torino		3				4
Japan						
Asakawa Experiment Forest Tokyo					1	2
Botanic Garden, Univ. of Kanazawa				1		2
Mexico						
Jardín Botánico, México D.F.		1				9
Netherlands						
Botanical Garden and Arboretum Wageningen		1				12
Philippines						
U.P. College of Forestry Botanical Garden, College					3	8

(TABLE 1 *continued*)

COUNTRY AND NAME OF INSTITUTION(S)	NUMBERS OF STAFF MEMBERS: ALGAE	FUNGI	LICHENS	BRYOPHYTES	PATHOLOGY *	ALL OTHER FIELDS
Poland						
Polish Academy of Science Arboretum, Kornik					1	16
Portugal						
Instituto de Botânica "Dr. Gonçalo Sampaio," Porto	2					6
Rhodesia						
National Botanic Garden, Salisbury					1	1
Romania						
Grădina Botanică, Univ. Cluj	1	3	1			10
Grădina Botanică, Univ. Cuza, Iasi	1	2				5
Singapore						
Botanic Garden	1	1				5
Spain						
Jardín Botánico Madrid	1					4
Switzerland						
Conservatoire et Jardin Botaniques, Genève				1		7
USSR						
Botanical Garden, Kaunas, Lithuania					1	6
Central Republic Botanical Garden Kiev, Ukraine					1	7
Botanical Garden, Kiev Univ.			1		2	6
Polar-Alpine Botanic Garden, Murmansk		1		1		4
Botanical Garden of Moldavia, Kishinev	1					14
Central Botanical Garden, Minsk					1	6

(TABLE 1 *continued*)

COUNTRY AND NAME OF INSTITUTION(S)	NUMBERS OF STAFF MEMBERS					
	ALGAE	FUNGI	LICHENS	BRYOPHYTES	PATHOLOGY *	ALL OTHER FIELDS
USSR (continued)						
Main Botanical Garden, Moscow					2	17
Central Siberian Botanical Garden Novosibirsk	1					9
Botanical Garden Petrozavodsk Univ.					1	3
Botanical Garden of Latvia, Riga					1	8
Arboretum, Sochy					3	11
Botanical Garden, Sukhumi, Georgia					1	4
Botanical Garden Tallin, Esthonia					1	9
Central Botanical Garden, Tbilisi, Georgia					1	13
State Botanical Garden, Yalta, Crimea					2	17
United Kingdom						
Univ. Botanic Garden Birmingham		1		1		5
Royal Botanic Garden Edinburgh		2				17
Botanic Garden Univ. Hull					1	3
Royal Botanic Garden Kew		4				46
South London Botanical Institute London		1				1
Agricultural Botany Field Station Botanic Garden, Reading					2	10
Royal Horticultural Society's Garden, Wisley					2	3
United States						
Grays Harbor Arboretum, Aberdeen,						

(TABLE 1 *continued*)

COUNTRY AND NAME OF INSTITUTION(S)	NUMBER OF STAFF MEMBERS					
	ALGAE	FUNGI	LICHENS	BRYOPHYTES	PATHOLOGY *	ALL OTHER FIELDS
United States (continued)						
Washington				1		2
Univ. Michigan Botanical Garden, Ann Arbor					1	10
Los Angeles State & County Arboretum					1	10
Brooklyn Botanic Garden					1	8
Sub-Tropical Experimental Station, Homestead, Florida					3	9
Christy Woods Arboretum, Muncie, Ind.					1	4
New York Botanical Garden, Bronx		3		2	2	17
Missouri Botanical Garden, St. Louis					1	16
State Arboretum of Utah, Salt Lake City				1		2
Yugoslavia						
Botanical Garden, Univ. Ljubljana	1					2

* Under Pathology are also included entries for bacteriology, virology, and entomology.

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Contents

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Cover: Lagenanthus princeps, *a shrub of the Gentian Family native to Colombia and Venezuela, whose red, yellow, and green flowers are outstanding in a group of plants well-known for their fine flowers. Photo: R. Weaver.*

Francis Parkman as Horticulturist

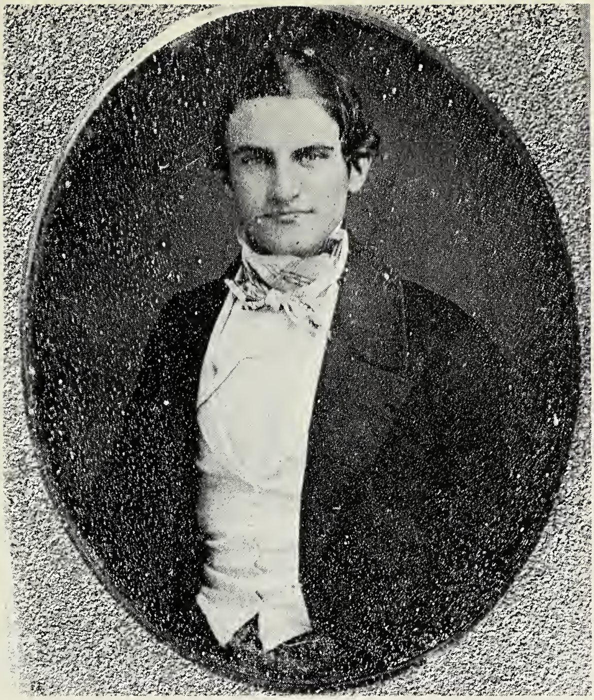
(This address was presented on Sept. 26, 1972 as part of the "Evening With Friends" series at the Case Estates, Weston. It is published here in its entirety. Ed.)

Samuel Eliot Morison, in the sketch that introduced *The Parkman Reader*, selected from the historical writings of Francis Parkman, remarked that "it used to be a joke in Boston that visiting Englishmen and Frenchmen asked to be presented to Mr. Parkman the historian, while the first person whom visitors from the Netherlands wished to see was Mr. Parkman the horticulturist." This dual career sprang, in an unpredictable combination, from the unusual circumstances of Francis Parkman's life and health. He was born in Boston on 16 September 1823 into a family of old Puritan stock that was both solvent and cultivated. His father, Francis Parkman of the Harvard class of 1807, was from 1813 to 1849 minister of the New North Church in Hanover Street, the handsome Bulfinch meeting house that in 1862 became St. Stephen's Roman Catholic Church. This Unitarian clergyman, who was a Harvard Overseer from 1819 to 1849, received the honorary degree of S.T.D. from the University in 1834. As the North End was becoming unfashionable, he preferred to live near Bowdoin Square, where his father, Samuel Parkman, a substantial shipowner and East India merchant, had a spacious house and garden between Chardon and Green Streets. In 1835, after the death of his mother, the Reverend Francis Parkman took over his father's house.

His son Francis Parkman was so high-strung a child that at the age of eight he was sent to live in Medford with his maternal grandfather, Nathaniel Hall, whose property adjoined the wild, rocky area that later became the Middlesex Fells Reservation. For four years the boy attended a local private school in Medford; out of hours he roamed in the woods, trapped squirrel and woodchuck, and generally acquired a taste for the wilderness. Even when he returned to his family in Boston at the age of twelve, he had more of the outdoors around him than was usual in the city, for behind Samuel Parkman's house, to which

his parents soon moved, were extensive terraced gardens, devoted to the cultivation of fruit trees, especially the Bergamot pear.

Just before his seventeenth birthday in 1840 Francis Parkman entered Harvard college with the class of 1844. He was a highly energetic, sociable, lively, and handsome young man. In later life his friends were struck by his resemblance to the Venetian equestrian statue of the Condottiere Colleoni; if one sought an analogy closer to home one might suggest that he had the pronounced jaw that characterizes many Saltonstalls. A member of an undergraduate literary club to which Parkman belonged recalled that he "even then showed symptoms of 'Injuns on the brain.' His tales of border life, his wampum, scalps, and birch-bark were unsurpassed by anything in Cooper." Parkman himself recalled: "All my summer vacations were passed in the forests chiefly those between Maine and Canada, or in Canada itself — or else in examining the scenes of battles, raids, and skirmishes in the various French and Indian wars." As a sophomore he sought the advice of Professor Jared Sparks, the first teacher of American history at Harvard, on historical sources concerning the Seven Years' War. Thus, at eighteen, between forests and books, his thoughts "crystallized into a plan of writing the story of what was then known as the 'Old French War,' that is, the war that ended in the conquest of Canada. . . . My theme fascinated me, and I was haunted by wilderness images day and night." Soon he "enlarged the plan to include the whole course of the American conflict between France and England, or, in other words, the history of the American forest." Parkman's zest for outdoor life led him during his summer wilderness holidays to feats of energy that wore out his companions. Such excess of activity, combined with hard study, having brought on a physical breakdown early in his senior year, his parents sent him to the Mediterranean for his health. Although he returned from Europe only in time to take final examinations, he received his A.B. on time in 1844, standing in the top third of his class and being elected to Phi Beta Kappa. He then entered the Harvard Law School, and received his LL.B. in 1846, fitting in between his two years of law a summer journey to the Great Lakes to see the physical scenes of the first book that he planned to write, *The Conspiracy of Pontiac.* Over forty years later he wrote: "The best characteristic of my books is, I think, that their subjects were largely studied from real life."



Francis Parkman at 20 years of age.

In May 1846 Parkman's cousin, Quincy A. Shaw, who was setting out on a hunting expedition in the Rocky Mountains, asked him to come along. The expedition, which gave Parkman adventure, acquaintance with a new frontier, and first hand sight of Sioux warriors on their own ground, provided unique experience with Indians and the wilderness. It also, through over-exertion, permanently undermined his health. By the time he returned home in October he was unable to use his eyes, and constantly suffered from insomnia and raging headaches. This second breakdown was particularly galling for a man who so prized robustness and strenuous activity. The remaining forty-seven years of his life were an unremitting struggle against the ills that he personified as "the enemy". Living in a darkened room, unable to read, he drafted the record of his Western travels with the help of a sister or friend who read his rough notes aloud and took down his dictation. So the account of this "tour of curiosity and amusement", which had had a serious purpose for him, reached book publication in 1849 as *The Oregon Trail.* Although "for about three years, the light of day was insupportable, and every attempt at reading or writing completely debarred", he bravely tackled *The Conspiracy of Pontiac*, relying upon faithful helpers to read him the as-

sembled sources and take down his drafts. Gradually "the enemy" retreated. By means of a frame with parallel wires placed over a sheet of paper, he became able to write slowly. In spite of these obstacles the book was completed in two years and a half, and published in two volumes in 1851, dedicated to his teacher Jared Sparks, by then president of Harvard.

By 1850 Parkman's health had so improved that on 13 May he married Catherine Scollay, daughter of Dr. Jacob Bigelow of Boston. A daughter was born in 1851 and a son, Francis, in 1853. The marriage proved an extremely happy one. Although they started housekeeping with an annual income of only a few hundred dollars, their finances soon improved, for after the death of his father in 1852 Parkman inherited property that made him comfortably off the remainder of his life. He soon bought three acres of land on the shore of Jamaica Pond, where, in a relatively modest cottage, they lived in the late spring, summer, and autumn, returning to Boston only for the winter months. Yet "the enemy" plagued even this happy scene, for in the autumn of 1851 Parkman had had an attack of water on the left knee, which led to almost permanent lameness. To give him an interest that would occupy him when physical pain kept him from intellectual concentration, his wife — as Henry Dwight Sedgwick noted in an early biography — "had given

him the suggestion, 'Frank, with all your getting, get roses.' Up he got and made a garden of roses. He had three acres, his man Michael, such enrichment of the soil as a horse, a cow, and a pig could supply, a few garden implements, and a wheeled chair, or in happy seasons a cane; with these he grew his beautiful roses." Parkman's knee complaint returned in force in the spring of 1853, incapacitating him completely for two years. A gardener's life at Jamaica Pond proved beneficial, however, for in 1855 he was back at his desk, working again on his great project concerning the French colonization of North America. He had not completed a volume, however, when even more severe blows fell. Young Francis, his only son, died in 1857 when only four years old; the boy's mother, who never completely recovered from this loss, died the following year, not long after giving birth to a second daughter. This dual tragedy precipitated another return of "the enemy". Gravely ill again, Parkman returned to Boston with his two motherless daughters to live with his widowed mother and unmarried sister Eliza at 8 Walnut Street.

In 1859 he went to Paris for medical treatment. Although specialists there achieved some improvement in his eyes and knee his recovery was never complete. Parkman's Harvard classmate Edward Wheelwright recalled how "when crippled by disease and needing two canes to support his steps, he might often be seen in the streets of Boston, walking rapidly for a short distance, then suddenly stopping, wheeling round, and propping himself against the wall of a house, to give a moment's repose to his enfeebled knee. Whatever he did, he must do it with all his might. He could not saunter, he could not creep: he must move rapidly, or stand still."

On returning from Paris, he went to Jamaica Pond, where his sister Eliza kept house for him and his daughters for over half of each year. To occupy himself in time of grief, when he could no longer concentrate on historical work, Parkman turned to horticulture. This, too, he did with all his might. Edward Wheelwright thus recalled his house: "It stood on rising ground, close to the shore of Jamaica Pond. Here he had his gardens and green-houses, and here he came early in the spring, and remained late in the autumn of every year. He kept on the pond a boat, into which he could step from his garden, and obtain in rowing the exercise that was essential to him when walking was difficult and painful. Frequent friendly visits to a muskrat, his neighbor on the shore of the pond, added to the pleasure he took in his boat. It was pleasant to

Parkman's home at Jamaica Pond.

visit him in his garden. He took not only pride in his flowers, but loved them, speaking of their characters, their habits, their caprices, as though they were sentient beings."

Francis Parkman's extraordinary energy and determination soon carried him into other fields of horticulture than his first love of roses. Howard Doughty in his 1962 biography of Parkman wrote: "Already in 1861, only a year or so after he had started gardening, his success was notable enough to put him in possession of a unique collection, his development of which, together with his work as a rosarian, gave him a permanent name in the annals of American horticulture. This was a collection of Japanese plants — the first of its kind to arrive in America — made in Yokohama by the botanist George B. Hall, and turned over to Parkman by his college mate and neighbor, Francis Lee, on Lee's departure for the war. Among other specimens, the collection contained the double-blossomed apple, now known as the Parkman crab, and bulbs of the *Lilium auratum*, which he was the first known person in America or Europe to bring to flowering outside Japan. With such material to work on, he devoted himself particularly to the hybridization of lilies, his chief triumph in this field being the *Lilium parkmanni*, a crossing of *L. auratum* with another Japanese stock, which he sold in 1876 to an English florist for one thousand dollars. But he was also among the foremost of American rose-growers. He is said to have had at one time over a thousand varieties in his garden, and *The Book of Roses*, which he published in 1866, was for many years a standard manual of the subject."

The extent of Francis Parkman's gardening and growing briefly tempted him into business, for in 1862 he formed a partnership with William H. Spooner, a nurseryman specializing in roses, who was active in the Massachusetts Horticultural Society. On 4 April 1862 he wrote to his cousin-in-law, Mary Dwight Parkman, then in Europe: "I am daily here — in Jamaica Plain — and am at last really busy, having formed a partnership with Spooner which will absorb all the working faculties I have left. So you find me a man of business. I am content with the move, & resolved to give the thing a fair trial and, by one end of the horn or the other, work a way out of a condition of helplessness. At all events, this is my best chance, & I will give it a trial. Spooner wants me to go to England & France in the Fall, to look up new plants. The thing has difficulties & risks, not a few under my circumstances; but it is attractive, & doubly so as it gives me a prospect of meeting you. So I cherish it, as probably an illusion, but still a very pleasing one." Parkman did not go to Europe in the autumn, as Spooner

had proposed; indeed the partnership in the nursery business was of the briefest duration.

Matters were quite different with the Massachusetts Horticultural Society, then located in its first Horticultural Hall in School Street on the site of part of the present Parker House. For several years Parkman had been exhibiting there; Howard Doughty notes that he won over three hundred awards from the society between 1859 and 1884. In 1863 when he became chairman of its library committee, he vigorously underlined the importance of that aspect of the society's work. In his first report Parkman made this classic statement: "To despise the aid of books is no evidence either of practical skill or good sense. This is particularly true of horticulture, in which the men of greatest practical eminence have without exception been those possessing the recorded knowledge of their predecessors or contemporaries. Horticulture is an art based on the broad principles of science, and has never found its most successful cultivators among those who have blindly ignored those principles." When the society moved in 1865 to the second Horticultural Hall in Tremont Street (between Bromfield and Bosworth Streets) Parkman asserted that the library, which extended across the entire front of the second floor, "may be said to bear to this noble building the relation which the brain bears to the body."

To a man who idolized courage and physical endurance as Parkman did, it was shattering to remain at home tending plants as his friends went into the Union Army. In September 1862 he spent a day and a night in camp at Readville with the Forty-fourth Massachusetts Infantry, of which Frank Lee, who had given him the Japanese plants, was colonel, and which numbered some forty Harvard alumni among its officers and men. Returning home he wrote of "the banners I was not to follow, the men I was not to lead, the fine fellows of whom I could not be one." But as he worked with his plants, his spirits and strength so returned that he began to dream of asking Louis Agassiz's daughter, Ida, to become his second wife, although carefully avoiding "the expression to her of anything beyond a simple though a very cordial friendship." Her marriage on 5 December 1863 to a dashing cavalryman, Major Henry Lee Higginson, who had returned to Boston to convalesce from severe wounds, ended such hopes for all time. Parkman remained a widower, bringing up his daughters with the aid of his sister. Despite such disappointments, Parkman's ceaseless activity with horticulture so benefited his health and spirits that before the

end of the Civil War he was again at work on his great historical project that he had set himself as an undergraduate two decades before. In March 1865 Little, Brown & Co. gave him proofs of *The Pioneers of France in the New World*, the first of six parts of *France and England in North America.*

Thenceforth he advanced steadily with the project, which was completed in nine volumes in 1892. This fortunate return to history did not mean the abandonment of horticulture, for he published *The Book of Roses* in 1866 and devoted his leisure to growing and hybridizing plants. Between 1867 and 1872 he published not only the second and third parts of *France and England in North America* but twenty-six articles in Tilton's *American Journal of Horticulture.* His historical friends understood the role that horticulture had played in his life. The Canadian historian, the Abbé Casgrain, who visited Parkman in May 1871, noted that, after his severe illness, "what agreed with him best was the cultivation of his garden, which he first oversaw while remaining seated near his employees. When his strength began to return, he tried to work with his own hands, while seated for the most part of the time in a folding chair. In this position he would cut his plants and the edge of his flower beds, or weed the ground nearby." The Abbé Casgrain was impressed by the tasteful simplicity of Francis Parkman's home at Jamaica Pond. He recalled particularly how "the interior of the cottage corresponded to the exterior; everything was comfortable, but no display of luxury. What I most observed, and comes back to me when my thought returns to that American home, was the perfume of flowers spread through all the rooms. Everywhere there were very beautiful bouquets, or rather bunches, composed principally of rhododendrons of the most delicate rose tints."

Soon after the Abbé Casgrain's visit, Parkman began the renovation and substantial enlargement of his Jamaica Pond cottage. The region now had an additional attraction for him, for in the spring of 1871 he had been appointed Professor of Horticulture at Harvard's Bussey Institution. This new undergraduate school of husbandry and gardening, which opened to students in September 1871, was located on a farm in the Jamaica Plain-Forest Hills section of West Roxbury, scarcely a mile from Parkman's house. On thus becoming an active member of the Harvard faculty, he resigned from the Board of Overseers, on which he had served since 1868, on the ground that it seemed "essentially unfit that the member of a supervisory body should himself be one of those whom it is his duty to super-

vise." Although Parkman planned and oversaw the building of greenhouses for the new institution, his career as a professor was almost as brief as that of a commercial nurseryman a decade earlier, for he resigned at the end of the academic year. The death of his mother in August 1871, followed by that of a beloved brother in January 1872, brought on a period of illness that made him feel unable to offer the course on plant propagation and the management of hothouses, nurseries, and gardens that the Harvard catalogue had announced for the following year.

Paradoxically one might claim that Francis Parkman's greatest contribution to horticulture was his resignation from the Harvard faculty, for his successor as Professor of Horticulture was the thirty-one-year-old Charles Sprague Sargent who created the Arnold Arboretum and ruled it until his death fifty-five years later. Although the evidence is only circumstantial, I firmly believe that Parkman must have played a crucial part in the selection of his successor. Otherwise, how would a young man who had stood eighty-eighth in his class of ninety on his graduation have reappeared ten years later on the Harvard scene as Professor of Horticulture? This then undistinguished scholar had entered the Union Army, which Parkman would have dearly loved to have done; made an extended Grand Tour of Europe, as Parkman had done before him more briefly, and settled down on his father's estate in Brookline, close to Parkman's smaller one, to occupy himself with horticulture, which was then a rich man's amusement rather than a profession. Parkman was thoroughly at home in the administrative stratosphere of a simpler Harvard, where people knew each other as they cannot today. He was re-elected to the Board of Overseers in 1874, and became a member of the seven-man Corporation in 1875, where he served until 1888. There being no body of professional candidates to draw from, President Charles W. Eliot had the previous year, when rounding up a faculty for the new Bussey Institution, filled the chair of horticulture with a Boston gentleman of property, living nearby, where he passed his time with the embellishment of his own grounds. President Eliot, facing so soon a second appointment in this unfrequented field, would, I suspect, have sought Parkman's suggestions about his successor. What could have been more natural than for Parkman to propose his young friend and neighbor? The promptness of Sargent's appointment in May 1872 supports this hypothesis.

Although Francis Parkman ceased to profess horticulture after a year, he continued to study and practice it. In part three of the second volume of the *Bulletin of the Bussey Institution*, Parkman published in 1878 an article on "The Hybridization of Lilies" that represented a dozen years of personal experimentation on this subject. He told how he had attempted to combine the two superb Japanese lilies, *L. speciosum* (*lancifolium*) and *L. auratum*, the former as female parent. After five or more years he was rewarded on 7 August 1869 with a bud that "proved a magnificent flower, nine and a half inches in diameter, resembling *L. auratum* in fragrance and form, and the most beautiful varieties of *L. speciosum* in color. In the following year, it measured nearly twelve inches from tip to tip of the petals, and in England it has since reached fourteen inches." Several years later Parkman sent a bulb of this new lily to Max Leichtlin of the botanical garden at Baden-Baden and another to the English grower Anthony Waterer, the proprietor of the Knap Hill Nursery at Woking, Surrey. Both responded with enthusiasm.

Leichtlin wrote to Parkman on 13 November 1875:

> In no small degree I am obliged to our mutual friend Mr. Sargent for his kindness to introduce myself to your notice, an introduction which I appreciate the more as it is to a gentleman who really seems to be a more successful hybridizer and grower of Lilies as even celebrated Marshall Wilder.
>
> You had the kindness to send me a splendid bulb of that costly and more remarkable hybrid *L. Parkmanni*. The bulb arrived in excellent condition and I call it welcome, and shall take every particular care to preserve and increase it; it is however so valuable a plant that I fairly cannot accept it and merely say my thanks! I rather regard it as still your property confided to my care to make sure of its preservation and propagation. Of course it will always be at your disposal.
>
> However I feel much obliged for your kind intention to procure to myself the pleasure of seeing it flowering; looking through my garden I find not much worth to reciprocate for but the only one bulb I can dispose of still of *L. Hansoni* and some 7 small bulbs of *L. polyphyllum* from the Himalayas. Through the kindness of Mr. Sargent you will receive the parcel.

> Here I beg to enclose a few seed of my own hybridising *L. giganteum* as parent female and *L. Thunbergianum* as male.

This was apparently sent by way of Professor Sargent, for in the Parkman Papers in the Massachusetts Historical Society is preserved this undated letter:

> Monday, P.M.
>
> Dear Parkman,
>
> The enclosed came for you today, The bulbs have not yet arrived, but they no doubt will in a day or two, when I will hand them over to Charlie.
>
> Your Lily seems to be having a great success, and you seem in a fair way to out strip even "celebrated Marshall Wilder."
>
> Come and see us when you can.
>
> Sincerely,
>
> C. S. Sargent

Anthony Waterer wrote on 18 October 1875 of the bulb sent to him: "I believe it was the most beautiful flower I ever beheld and that was the opinion of all who saw it. It must be a most desirable plant and if it is not distributed will doubtless prove of considerable commercial value. I note your kind promise to communicate with me before parting with any more. I shall be very glad of the opportunity of purchasing any you have to spare." This letter led to Parkman selling the lily to Waterer for exclusive distribution, apparently for the thousand dollars mentioned by Parkman's earliest biographers. Waterer gave it the name of *Lilium Parkmanni.* Parkman on 15 January 1876 wrote Waterer thus in regard to terms:

> My proposal is to send you *all* the bulbs of the hybrid *L. Parkmanni* which are in my possession..
>
> These consist of *three* about as large as I sent you, and two or three smaller ones. The three larger ones (just mentioned) grow attached together in one pot, and each threw up a stem last season as large as a small goose quill.
>
> *I do not propose to reserve any bulbs for myself or Mr. Sargent*; but to take the risk of success or failure in raising bulbs from the scales of which I spoke in my last. If I succeed in doing so, I shall reserve two of the bulbs thus obtained — one for myself, and the other for Mr. Sargent.

> All the rest will be sent to you, as soon as they are strong enough to bear transportation.
>
> The only bulbs which have left my hands are one sent to you and one to Mr. Leichtlin. I have lately received a letter from Mr. L. He promises not to part with the bulb or with any bulbs that may be raised from it; and I believe his word is entirely to be trusted.

An account of the lily appeared in England in the March 1876 issue of *Florist and Pomologist*, illustrated by a colored plate.

After completing a decade as Chairman of the Library Committee of the Massachusetts Horticultural Society, Parkman was elected president on 7 November 1874. Although it was the custom only to seek a portrait of a president on his retirement, a committee was appointed for such a purpose one month after Parkman's election on the ground that his "valuable services to horticulture should not be entirely eclipsed by this world-wide reputation as a historian." Accordingly a bust of Parkman by the Irish-born Boston sculptor Martin Milmore was completed and in Horticultural Hall early in February 1876, almost two years before its subject, having declined re-election, made his farewell address as president on 5 January 1878.

Early in the 1880's as the tempo of his historical writing and his lameness increased, Francis Parkman gradually withdrew from horticultural activities beyond the care of his grounds. The beauty of this place above Jamaica Pond continued to attract his many friends. Henry Dwight Sedgwick wrote of the place a decade after Parkman's death:

> Sometimes in the richness of the blossoming time the colors were too heavily laid on by the horticultural hand;
>
> The fayre grassy grownd
> Mantled with green, and goodly beautifide
> With all the ornaments of Floraes pride,
> Wherewith her mother Art, as halfe in scorn
> Of niggard Nature, like a pompous bride
> Did decke her, and too lavishly adorne —
>
> was too red and pink and yellow. The azaleas, rhododendrons, magnolias, syringas, lilacs, and the big scarlet Parkman poppies were too bold for a less scientific eye, and overshadowed the columbine, foxglove, larkspur, violet, even the Japanese iris, whose seeds had been fetched from the Mikado's garden, and all the wee, modest flowers; but people would drive thither many miles to see the splendor of the blossoms.

> The garden was of modest dimensions and sloped down sharply to the shore, so that the little walk from the house to the dock on the pond's edge ran past all the vegetable friends, trees, shrubs, and plants. There was a tall, wide-spreading beech, elms sixty feet high, a big chestnut, a tulip, a plane-tree, two white oaks, a sassafras, Scottish maples and scarlet maples, lindens, willows, pines, and hemlocks; and holding themselves a little aloof, as befittted their rarity and breeding, a Kentucky coffee-tree, a gingko, the magnolia acuminata, and the Parkman crab, first of its kind in New England, radiant with its bright-colored flowers.

Francis Parkman died on 8 November 1893, a year after the publication of the final part of his great historical work. Soon after his death his property on Jamaica Pond was bought by the Commonwealth of Massachusetts to enlarge the Olmsted parkway that extends from the Back Bay to the Arnold Arboretum and beyond. A new road, bearing his name, runs through the former location of Parkman's rose garden. On the site of his house was placed an allegorical monument by Daniel Chester French with a bronze bas-relief of Parkman. Alas, the portrait relief has recently been stolen by vandals. At the base of the monument are carved these lines: "Here where for many years he lived and died friends of Francis Parkman have placed this seat in token of their admiration for his character and for his achievements." The chairman of the committee that raised the funds for this memorial was Major Henry Lee Higginson, founder of the Boston Symphony Orchestra and Parkman's successful rival for the hand of Ida Agassiz in 1863.

Although Francis Parkman's garden has vanished, the study in which he did much of his writing is still preserved, nearly eighty years after his death, substantially as he left it in 1893. His mother in 1864 bought a pleasant early nineteenth century brick house on the lower slope of Beacon Hill, where he and his children and his sister Eliza lived with her in the winters. On Mrs. Parkman's death in 1871 the house was left to her daughter Eliza, with whom Parkman continued to live during the winter, just as she lived with him at Jamaica Pond during the more clement months of the year. The 50 Chestnut Street house eventually passed to the Misses Cordner, nieces of Francis and Eliza Parkman, who made few changes in it, piously keeping his third floor study much as he had left it, save for his historical books and manuscripts, which were given, respective-

ly, to the Harvard College Library and the Massachusetts Historical Society. When Miss Elizabeth Cordner died in 1955 at a great age, 50 Chestnut Street was sold, but her heirs generously gave much of the furniture to the Colonial Society of Massachusetts, which had recently come into the ownership of a large Bulfinch house at 87 Mount Vernon Street. During the autumn of 1955 the contents of Parkman's study were moved, lock, stock, and barrel, to the Colonial Society's house, together with doors, mantlepiece, gas fixtures, and other details that permitted the reconstruction of this touching little room on the fourth floor of 87 Mount Vernon Street in a manner that would make Francis Parkman feel at home. Particularly so because in a corridor outside the study stands his wheel-chair, while on the walls hang numerous photographs of his house and garden at Jamaica Pond, and a print of *Lilium Parkmanni*, taken from his desk and framed. As I had the pleasure eighteen years ago of transferring Parkman's Lares and Penates from one part of Beacon Hill to another, I have welcomed the opportunity to remind the Friends of the Arnold Arboretum of the horticultural activities that he carried out on the shores of Jamaica Pond, so close to the Arnold Arboretum, whose first director I firmly believe he chose.

WALTER MUIR WHITEHILL
Director and Librarian, *Emeritus*
Boston Athenaeum

Notes

Most of the details of Parkman's career as a horticulturist are scattered through his biographies by Charles Haight Farnham (1900), Henry Dwight Sedgwick (1904), Mason Wade (1942), and Howard Doughty (1962). Wilbur R. Jacobs, who edited Parkman's letters (1960) has another biography in project. Edward Wheelwright's memoir is in *Publications of the Colonial Society of Massachusetts*, I (1892–1894); Parkman was elected to that society, which today preserves his study, at its first meeting on 18 January 1893. Samuel Eliot Morison's *The Parkman Reader* (1955) is a delightful selection from Parkman's work by the twentieth century historian who has best emulated Parkman's style and practice of seeing at first hand the scenes that he describes. Selections from the letters of M. Leichtlin, Anthony Waterer, and Charles S. Sargent are published by permission of the Massachusetts Historical Society which owns Parkman's papers.

Francis Parkman and friend on porch of his Jamaica Pond home.

Streptocarpus 'Constant Nymph' and Its Mutants

It appears that the Arnold Arboretum has introduced to American gardeners what may turn out to be the most exciting group of new house and greenhouse plants for a long time. It all started with a gift of a few plants of *Streptocarpus* 'Constant Nymph' to Dr. Richard A. Howard, Director of the Arboretum, from the greenhouses at Dunbarton Oaks some years ago. The potentials of this cultivar as a remarkable house plant became obvious very quickly. It propagates with speed and ease and its magnificent blue flowers are produced in abundance throughout almost the whole year. It fully justifies its name.

We cannot take credit for introducing 'Constant Nymph' in America but apparently we are responsible for introducing its five remarkable new mutants, 'Blue Nymph', 'Cobalt Nymph', 'Mini Nymph', 'Netta Nymph' and 'Purple Nymph'.

To avoid future confusion, it seems wise to get the story in print. Dr. W. J. C. Lawrence, while working on color inheritance in plants at the John Innes Horticultural Institution in England in the 1940's, crossed a particularly good hybrid streptocarpus called 'Merton Blue' with *Streptocarpus johannis*. One of the seedlings of this cross was named 'Constant Nymph'. Under normal house conditions it will bloom continuously from April to November. With supplementary lighting it can be kept in flower all year around.

The unfortunate name, *Streptocarpus*, can be quickly dismissed as being no more than a description of the ripened seed pod. It means "twisted fruit". This genus of predominantly African plants has interested both gardeners and scientists for a long time for different reasons. Several unusual characteristics appear in many of the members of the genus. 'Constant Nymph' illustrates some of them. There appears to be no true stem or conventional growing point to the plant. The leaves seem to grow from the upper surfaces of the bases of other leaves. The flowers appear to arise from the upper surfaces of the petioles. As a house plant it can suffer considerable abuse and survive. If water is deliberately withheld from one

Streptocarpus *'Constant Nymph'. Photo: R. Spurr.*

of these plants for as long as a month, turgor is restored to the dead-appearing, limp leaves in a matter of hours after watering.

Since 'Constant Nymph' and its mutants do not come true from seed, they must be propagated vegetatively. Leaf cuttings are the most effective method for as many as 100 new plants may be obtained from one leaf. Two main methods of preparing the leaves are used. The leaf blade may be cut crosswise into several pieces. The proximal ends are then inserted into a rooting medium. Or the leaf blade may be split down the middle the long way, removing the main vein and placing the two large pieces of the leaf blade with the long cut edge in the rooting medium. A great many plantlets will result from either method. A temperature of around 70–75 degrees F seems optimal for rooting. Roots should appear in about two weeks. In another two weeks independent leaflets appear which eventually grow into small plants. Progeny should not be separated from the old leaf until each plantlet has roots developed at the base of its own leaves. When all the new plants are eventually removed from the old leaf, these leaf

sections may be replaced in the rooting medium and another batch will develop.

It is sometimes possible to get even a third batch of plantlets but with reduced results. The basal portion of the leaf from which the flowers arise, should not be left on during rooting. If this is not removed, roots will appear on this area and flowers usually develop without the formation of new plantlets. Not removing this part at the base of the leaf is the main reason some leaves do not propagate well. Fertilizing nutrients should not be included in the rooting medium because excessive activity results in producing an abundance of flowers. The result is a heavily-flowered, single-leaved plant with few plantlets.

In March, 1969, the writer was fortunate in being able to spend about a week in the Netherlands. He was additionally fortunate in having a close friend, Dr. Robert Legro, as host during much of this time. During visits to the horticultural experimental station at Wageningen which involved nearly two days, some time was spent with Dr. C. Broertjes at the Institute for Atomic Sciences in Agriculture. He was doing experimental work involving radiation on several kinds of plants. One of the plants was 'Constant Nymph'. Dr. Broertjes explained a remarkable characteristic of this plant as well as some of its relatives which made them particularly valuable as experimental material. When he radiated whole mature leaves, each new plantlet that developed arose from a single mutated leaf cell. The resulting entire plant possessed the mutated trait or traits and could be readily propagated. The troublesome problem of chimaeras common in other plants treated in this manner was eliminated.

In his preliminary experiments, Dr. Broertjes produced 1,650 mutants. Five of these eventually received Certificates of Merit in the spring of 1969 and are the named mutants with which we are concerned.

In August, 1969, we requested from Dr. Broertjes propagation material of whatever mutants he cared to release. The first shipment consisted of unrooted leaves. Due to a delay enroute almost all arrived in a deplorable state of decay. We received a second shipment on November 3, 1969. These were leaves in excellent condition with well developed plantlets attached. They included the previously mentioned mutants. In the greenhouse at the Case Estates all the plantlets had flowered by May 1970. 'Blue Nymph' has light blue flowers with a small

pale greenish-yellow blotch in the throat; 'Cobalt Nymph' has intensely dark blue flowers with a small greenish-yellow throat-blotch. This tetraploid has a compact habit of growth and flowers of heavy substance. It seems to be more difficult to propagate than the others. 'Mini Nymph' has flowers very much like 'Constant Nymph' with a yellow throat blotch. It is very free-flowering and makes a fine compact plant. 'Netta Nymph' has dark blue flowers with distinctive darker reticulate venation on the petals. It is also very free-flowering. 'Purple Nymph' with its rich purple flowers and small yellow throat blotch seems to make the largest plants and be the most vigorous of the five.

The response of the general public to these new cultivars can best be described as covetous. On "Friends of The Arnold Arboretum Days" when a mixture of excess Arnold Arboretum plant material is sometimes offered free to Friends, the streptocarpus plants are always the first to be taken.

The September/October 1970 issue of *The Gloxinian* featured a striking color plate of 'Netta Nymph' on its cover. This issue contained an article, "New Streptocarpus Varieties" by Dr. Carl D. Clayburg. He reviewed Dr. Broertje's work, described the new mutants in some detail and mentioned that the Arnold Arboretum of Harvard University was growing them and planned to release some propagative material soon to commercial growers. The Kartuz Greenhouses in Wilmington, Massachusetts had already received propagative material from the Arboretum before the article appeared. Additional leaves were sent to Wyrtzen Exotic Plants in Floral Park, New York and the L. Easterbrook Greenhouses in Butler, Ohio.

On June 9th, 1970 we had been given full freedom by Dr. de Zeeuw, Director of the Institute for Atomic Sciences in Agriculture at Wageningen, to do with these mutants as we wished. Dr. Broertjes stated that "they are not covered by any kind of protection; the only thing we did was to have them registered and commercialized." Recently, when the question arose as to whether or not the Arnold Arboretum had actually been first to introduce these mutants to American gardeners, Dr. Broertjes responded in a letter dated June 22, 1972 saying that, "so far as I know we did not send leaves to other persons or institutions in the United States of America."

There is more to come, for developments have not yet ended. A white flowered spontaneous mutant has occurred known as 'Maassen's White'. From this cultivar by use of irradiation and colchicine a number of mutants and tetraploids have been pro-

duced. We have been promised propagative material of 'Maassen's White'. We will hope for propagative material of two other cultivars that are expected to be released in 1973. One is a "mini-white type" and the other a white which is described as a tetraploid with very large flowers.

GEORGE H. PRIDE

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In Search of Tropical Gentians

Gentians need no introduction to most people interested in plants. Several species, particularly the Fringed Gentian (*Gentianopsis crinita*), are among the most beautiful and avidly sought-after wildflowers in the eastern United States. Others, mostly alpine and subalpine species of the Old World such as *Gentiana acaulis*, *G. scabra*, and *G. septemfida*, are becoming increasingly popular as rock garden subjects. But the Gentian Family, or Gentianaceae, includes a diverse group of plants, many of which are unfamiliar to the layman and probably would not be recognized by him as gentians. This is particularly true of those members of the family that are native to the American tropics. While the gentians (in this article, the term "gentian" will refer to any member of the family) of the North Temperate Zone are entirely herbaceous, many tropical species are shrubs or even small trees.

My interest in tropical gentians began while I was a graduate student at Duke University; and it has continued, giving me an opportunity to travel to various parts of the American tropics. In this article I will recount some of my impressions and experiences of these travels, as well as discuss a few of the genera with which I came into contact.

My thesis research was concerned with the genus *Lisianthius*, which includes 27 species distributed in Mexico, Central America, and the Greater Antilles. Plants of this genus are herbs, shrubs, or small trees with flowers to 2 1/2 inches long, usually bright yellow in color. A few of the species have red or greenish flowers, but the most extraordinary one, aptly named *Lisianthius nigrescens*, or Flor del Muerte (Flower of Death) in its native Mexico, has flowers that are very nearly black. In certain light, a slight reddish tinge may be observed, but these are the blackest of any flowers I have ever seen.

My first trip in search of *Lisianthius* took me to the island of Jamaica, with my sister, Sylvia, as a companion. This was my first experience with a tropical flora, and the variety of unfamiliar plants was quite bewildering; but it was a successful trip. We had unlimited (and free) use of a Land Rover, with which we were able to travel over much of the island, and I

was able to collect all eight of the Jamaican species. This is not as impressive a feat as it sounds, since most of the species are found along roadsides. One of them, *Lisianthius longifolius*, locally called the Jamaican Fuchsia (although it resembles a Fuchsia only in the shape of its flowers, and then only vaguely) is common and conspicuous, and both my sister and I became adept at spotting it while speeding along at 50 mph. or negotiating the frequent hairpin curves on the tortuous mountain roads.

During my travels through Mexico and Central America in search of *Lisianthius*, I have come across several other gentians, perhaps the most noteworthy of which are the species of *Voyria*. These delicate plants, seldom more than 6 inches tall and with the leaves reduced to inconspicuous scales, are without chlorophyll and therefore unable to manufacture their own food. They must obtain their nourishment from other plants, either living or dead. Most species have flowers 1/4 to 1/2 inch across, but some are much larger; the color varies from white through pink, purple, and yellow.

I first saw these plants in the dense forests of Barro Colorado Island, a natural preserve in the middle of the Panama Canal maintained by the Smithsonian Institution. The field station for visiting scientists has comfortable accommodations, and, most welcome in the steamy climate of sea-level Panama, an air-conditioned laboratory. But it is the animals that are perhaps Barro Colorado's most spectacular feature. Nowhere else in Central America can such a variety of wild mammals be seen under such favorable circumstances. Three species of monkeys — Capuchins or White-faced, Spiders, and Howlers — are conspicuous, the last particularly so because of the loud booming calls of the males. Sloths and Tamanduas (a kind of arboreal anteater) are frequently seen in the trees close by the station, and coati-mundis, peccaries, and even a tapir came by for handouts.

Although there are a number of interesting and beautiful species of Gentianaceae in Central America, there are many more in South America. In fact there are probably more species of gentians on that continent than on any other. I had my first look at South America in the fall of 1968, when I spent three days in Colombia. I had little time to sightsee, but I did have an opportunity to visit the high elevation vegetation, or paramo, some of which is accessible by cable-car from Bogotá. I saw enough to want very much to return. I had my chance four years later when a collecting trip took me back to Colombia, as well as to Venezuela and Peru.

Gentianella nevadensis (*above*) *and* Gentiana sedifolia (*below*), *both twice life size. These photographs illustrate one of the primary differences between the two genera.* Gentiana *has an extra fold between each of the corolla lobes, in the case of this species at least, giving the appearance of having ten "petals". These folds are absent in* Gentianella.

Photo: R. Weaver.

The term "paramo" is used to denote a vegetation type that is peculiar to the Andes of Venezuela, Colombia, and Ecuador between 10,000 and 15,000 ft. elevation. Although in their lower reaches patches of paramo are often interspersed with stunted trees, the upper levels are truly alpine; rain and fog are frequent, and the temperature usually hovers near the freezing point at night. The most characteristic plants of the paramos are the Espeletias (or "frailejones" to the natives), members of the Compositae, the same family that includes daisies, dandelions, and sunflowers. There are many species, with various habits of growth, but the most common ones are characterized by a dense rosette of silvery or whitish leaves which is often 2 feet across. As the plants grow older, the stem elongates and the rosette is borne above the ground, sometimes to a height of 5 feet or more, with the old, dead leaves hanging down like a skirt. The "flowers" or heads, borne singly or in clusters, arise from the rosette on long stalks. In a landscape dominated by Espeletias, especially in the fog-filtered sunlight so characteristic of these areas, the aspect is almost unearthly.

Paramos are delightful places for a botanist. Besides the Espeletias, many other plants are present, some of them "belly plants" (best observed by lying on one's belly), and others with large, brightly colored flowers. Many of the genera — *Lupinus*, *Senecio*, *Bidens*, *Aster*, *Oxalis*, *Cerastium*, *Draba*, etc. — are familiar to us from the North Temperate zone. Others of course are primarily Andean, such as the beautiful, azalea-like *Befaria*, and *Bomarea*, an Amaryllidaceae with red and yellow flowers that often grows as a vine.

I had the good fortune during my trip in the fall of 1972 to be able to stay with a friend, a roommate from my graduate student days, who was studying Espeletias. Our cottage, at 11,500 feet right in the middle of the paramos, was about 30 miles west by good road from Mérida, Venezuela. I have never stayed at a more delightful place. Set beside a subalpine lake, full of trout with Blue-winged Teal dabbling in the reeds, with dandelions and white clover by the doorstep, it was overlooked by a snow-covered mountain with a waterfall cascading down its slopes, and surrounded by miles and miles of Espeletia-dotted paramo. The mixture of things familiar and unfamiliar was indescribably beautiful by day or night, in sunshine or rain.

Three genera of gentians are common and conspicuous in the paramos. *Gentiana sedifolia* is the only member of its genus in the Andes. It is a diminutive plant, often indistinguish-

Paramo surrounding Laguna Mucubají at 11,500 feet in the Andes of Venezuela. The conspicuous whitish plants are Espeletia schultzii.
Photo: R. Weaver.

able from the mosses among which it grows unless its flowers are open. This is truly one of the gems of the paramo. The flowers are about 1/2 inch across and of a brilliant sky-blue color; as is common in this genus, pure white variants are occasionally found. Many gentian flowers are sentitive to changes in light and/or temperature, but those of this species are particularly so. Even a cloud passing over the sun will cause them to close.

In contrast to *Gentiana*, perhaps 300 species of *Gentianella* are native to the Andes. Each high mountain seems to have its own species, and the range of flower color and form is incredible. A common type, exemplified by *G. nevadensis*, the most familiar species of the Venezuelan Andes, has flowers which are white to pale lilac with dark purple veins. Those of other species are pure white, purple, yellow, orange, or red.

The third genus of the paramos is *Halenia*. Like *Gentiana*

Symbolanthus tricolor (*life size*), *photographed near Bogotá, Colombia; a shrub to five feet tall with beautiful rose-pink flowers.*

Photo: R. Weaver.

and *Gentianella*, it is widespread in other parts of the world. A number of species occur in the mountains through Central America and Mexico into the southwestern United States; and *H. deflexa* is found in the north central and northeastern parts of our country and adjacent Canada. In addition, a few species are Eurasian. *Halenia* is unique among gentians in having four usually conspicuous spurs at the base of the corolla. Otherwise the flowers of most species are not particularly noteworthy, often being as green as the leaves.

Immediately below the paramo and grading into it is a forest type variously known as cloud, mossy, or elfin forest, or, unromantically, subalpine scrub. The trees here are low in stature with gnarled branches, and they are often heavily covered with epiphytes, particularly mosses, liverworts, and lichens; all these attributes are probably a direct response to the very frequent fog. This forest type occurs at higher elevations throughout tropical America, and although the plant species may change from place to place, the aspect remains much the same.

Three genera of gentians are characteristically found in the elfin forests. The largest of these, both in the number of species and the stature of the individual plants, is *Macrocarpaea*. There are perhaps 50 species, of which a third remain to be scientifically described. These plants are usually small trees, up to 15 feet tall, with large glossy leaves, and pale yellow or greenish flowers as much as 3 inches long and 2 1/2 inches across. Although the color of the flowers is not outstanding, their large size and the profusion in which they are borne produce a spectacular display when the plants are in full bloom.

In many species I noticed that a rather large percentage of the flowers appeared to have been torn open by something. This was quite a mystery until I realized these plants are probably pollinated largely by bats. These creatures, in search of nectar, are notoriously rough on the flowers from which they get their snacks.

I have collected 10 species of *Macrocarpaea*, from Jamaica to southern Colombia, but perhaps the one I remember most vividly is a rather ordinary looking one from Venezuela. When I found it, I recognized at once that it was a species new to science — which was exciting — but almost immediately my attention was drawn to a movement on the ground nearby. The stream by which the plant was growing was literally crawling with dozens of the most extraordinary frogs. These creatures were sluggish and easy to catch — unusual enough for a frog

Macrocarpaea pachyphylla (*1/4 life size*), *one of a genus of shrubs common in high elevation forests in the Greater Antilles, Central America, and northern South America. Photo: R. Weaver.*

— but their color, lemon yellow with ruby eyes, was their most startling attribute. How I wished that I could have taken a few home for my vivarium.

In the lower parts of the elfin forest, another gentian is to be found. Plants of the genus *Symbolanthus* are usually shrubs less than 5 feet tall, and the flowers of many species are truly beautiful. Up to 5 inches long and a delicate rose-pink with white lines on the inside of the corolla lobes, they are not easily overlooked. They are unfortunately scentless, as are most of the family.

Still another shrubby gentian of these forests, but only in that part of the Andes near the Colombia-Venezuela border, is *Lagenanthus princeps*. This plant has been called the "prince of the gentians" and deservedly so. The tubular flowers are 6 to 7 inches long, bright red at the base, changing to yellow in the middle, and finally lime green at the tips. Although I have seen flowers that are more beautiful, I have seen few that are more spectacular. As one travels through the tropics (or anywhere else for that matter), one finds that the plants grown ornamentally are seldom natives of the area; in fact roses and geraniums are far from uncommon. It is thus a tribute to the beauty of *Lagenanthus princeps* that people in the area where it is native often grow it beside their homes.

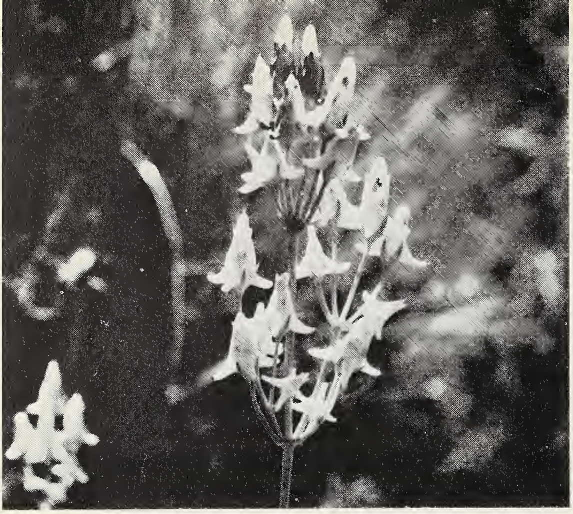
The lowlands of South America are poor in gentians. The most conspicuous genus is *Chelonanthus*, and one of these, *C. alatus*, a weedy plant of roadsides and cut-over fields, is the most common and widespread species of the American tropics. Unfortunately it is also the least attractive. The plants are tall and coarse and the flowers are green and inconspicuous. It does have a redeeming quality, however; according to Dr. Bassett Maguire of the New York Botanical Garden, the Indians of Guyana boil it up and use the extract to make a glaze for their pottery.

Several of the more spectacular tropical gentians have been grown as greenhouse plants. *Lisianthius longifolius* was cultivated in England as early as 1793, and several species such as *Purdieanthus pulcher*, a beautiful red-flowered shrub, were first described from cultivated material. But most species gradually disappeared from cultivation, although *Lisianthius nigrescens* is still reportedly grown in the Royal Botanic Gardens at Kew.

I have grown various species of *Lisianthius* for several years, both in the greenhouses of Duke University and here at the Arnold Arboretum. Cultural requirements are relatively simple for these plants. The seeds germinate after about a month

Lisianthius nigrescens *(1 1/2 times life size), a rather weedy plant whose nearly black flowers are a common sight along the Interamerican Highway in southern Mexico. Photo: R. Weaver.*

Chelonanthus alatus (*life size*), *a common weedy plant along roadsides in Central America and northern South America. Photo: R. Weaver.*



Halenia asclepiadea (*life size*), *showing the spurs at the base of the flowers that set this genus apart from all other gentians.*
Photo: R. Weaver.

and the seedlings grow slowly during their first year. After that growth is rapid, and most species have flowered by the end of the second year. They are not fussy about soil, but they appear to do best with a periodic sprinkling of lime. Although the flowers and foliage of most species are attractive, *Lisianthius* can hardly be recommended as a good greenhouse subject. The plants get to be quite coarse and leggy, assuming a most ungraceful appearance after several years. However, because of the unusual color of its flowers, some people might consider *Lisianthius nigrescens* to be worth the trouble. Several members of my family have grown these plants on window ledges in their homes, with varying degrees of success.

I have hybridized several of the species, but to date, none of the resulting progeny has proved more satisfactory horticulturally than both of the parents. Second generation hybrids are being grown at present, though none has reached maturity.

Although the South American species of *Halenia* and *Gentianella* are primarily plants of alpine areas, temperatures in their native habitats seldom drop more than a few degrees below freezing. Therefore they would doubtless prove tender in most parts of the United States. I have seedlings of a number of species, but they will be grown indoors.

The flowers of *Lagenanthus princeps* and several of the *Symbolanthus* species are so spectacular that, in my opinion at least, these plants are worthy of cultivation no matter how ungainly they might grow to be. I brought seeds of both genera from South America. However, judging from conditions in their native habitat, and from the experience of the British more than a century ago, a cool greenhouse will be needed to raise them to maturity.

RICHARD E. WEAVER

Plant Registrations

The Arnold Arboretum acts as the International Registration Authority for cultivar names in the genera *Chaenomeles*, *Cornus*, *Fagus*, *Forsythia*, *Gleditsia*, *Lantana*, *Malus* (ornamental species), *Philadelphus*, *Pieris*, *Ulmus*, *Weigela* and any other miscellaneous woody genera to which an International Registration Authority has not been assigned. In addition, we are accepting registrations for new cultivars of conifers originating in this country to be forwarded to the Royal Horticultural Society which acts as the I.R.S. for that group.

Every so often during the past 12 years new cultivars of woody plants registered by the Arnold Arboretum have been published in Arnoldia (see Arnoldia, Vol. 21: 9–18; 31–34; 39–42; 47–50. Vol. 23: 17–75; 77–83; 85–92; 111–118. Vol. 24: 1–8; 41–80. Vol. 26: 13–16. Vol. 27: 16–66. Vol. 29: 1–8. Vol. 30: 251–260. Vol. 32: 277–287).

Included here are those cultivars which have been registered between October 1, 1972 and February 1, 1973. All correspondence concerned with more information, plants, or propagating material of these plants, should be directed to the various originators or introducers, not the Arnold Arboretum.

Aesculus parviflora var. *serotina* 'Rogers'

A new cultivar of the Late Bottlebrush Buckeye is registered by Prof. Joseph C. McDaniel, Division of Ornamental Horticulture, University of Illinois, Urbana, Illinois. The original plant, which is now nine years old, originated from seeds collected from a specimen of *A. parviflora* var. *serotina* at the Missouri Botanical Garden. In Prof. McDaniel's words . . . "*A. parviflora serotina* 'Rogers' is a showy flowered cultivar which is especially easy to grow from root pieces divided in early spring. Its inflorescences are abundantly produced and are longer than those I have seen on most other clones even of the late variety. Unlike most other clones I have observed in either variety, (*A. parviflora* and *A. parviflora serotina*), it forms adventitious shoots both from the larger roots near the crown of the plant, and from severed root pieces farther out. Like other clones, it sometimes also layers itself naturally from prostrate branches

arising in the crown region, but the true root-cutting method seems to offer the fastest and most economical method of increasing it for nursery propagation. The cultivar name honors Dr. Donald P. Rogers, Professor of Mycology at the University of Illinois, in whose front yard the original plant grows."

Propagating material has been offered to growers, and commercial introduction is expcted in 1975. Divisions are to be sent to the Arnold Arboretum for trial in our collections. The name, with description, was originally published in *American Horticulturist* 51(3): 11 (1972).

Acer japonicum 'Green Cascade'

A new cultivar of Japanese Maple registered by Mr. Arthur Wright, Canby, Oregon. The original plant is now fifteen years old and was grown from open pollinated seed collected from *A. japonicum* 'Aconitifolium'.

As compared with *A. japonicum* 'Aconitifolium', the leaves of this cultivar are more delicately divided, and normally smaller in size. Its most outstanding characteristic is its prostrate or cascading habit which causes the plant to grow as a shrub rather than as a small tree.

Acer palmatum 'Sherwood Flame'

A new cultivar of Japanese Maple which is being registered for Mr. W. J. Curtis, Wil-Chris Acres, Sherwood, Oregon by Mr. J. D. Vertrees, Rt. 2, Box 593, Roseburg, Oregon 97470.

The original plant is now about twenty years old, and is characterized mainly by its good red foliage and desirable serration on the edges of the leaves. As compared with *Acer palmatum* 'Burgundy Lace', it retains its red foliage better, especially when grown in full sun. This color is retained through the summer months and does not fade to bronze or green as is the case with so many other cultivars in this group. It is a vigorous plant, of upright habit, with the same limits of hardiness and adaptation to soils as other *Acer palmatum* varieties.

Acer platanoides 'Crimson Sentry'

This new cultivar of Norway Maple, (Plant Patent #3258), is registered by Mr. Peter K. McGill, A. McGill and Son, Fairview, Oregon 97024. It originated in that nursery in 1970 as a sport of *A. platanoides* 'Crimson King'. It was first introduced to the trade in 1972, and the original publication of the name is to be found in the A. McGill & Son price list for that year. *A. platanoides* 'Crimson Sentry' is distinguished from other va-

rieties of Norway Maple mainly by its upright, columnar nature and very profuse branching habit. The leaves are smaller than *A. platanoides* 'Crimson King' and cupped in form. The lower two lobes are very small, giving a three-lobed effect to the leaf.

Hardiness limits and adaptability to various soil types are, at present, unknown for this cultivar, but the Arnold Arboretum is to receive plants for trial in Boston.

Cornus florida 'Rainbow'

A cultivar of Flowering Dogwood registered by Mr. J. Frank Schmidt, Jr., J. Frank Schmidt & Son Co., 23000 S. E. Stark Street, Troutdale, Oregon 97060. It originated on the property of Mr. Armond Marzilli, 5433 Everhard Drive Northwest, Canton, Ohio in 1964 from a specimen of normal *Cornus florida* which was run over by a truck and broken. In the multiple growth that resulted, one of the stems had multi-colored leaves. Budwood from this sprout was obtained in 1964 by the J. Frank Schmidt & Son Co., who have since offered it in their catalog as *Cornus florida* 'Rainbow', Plant Patent #2743.

In the words of Mr. J. Frank Schmidt, Jr. . . . "the leaves of our tree in autumn color are not only multi-colored, but the areas of darker coloration are centrally oriented, and there is a 'leaf within a leaf' effect. The darker areas of coloration are distinctly defined and in many places terminate at vein lines . . . The darker areas vary in form and shape from leaf to leaf, but in general terminate short of the side edges of the leaf. The darker areas appear in spring, dark green in color surrounded or positioned on a matrix of lighter green. Thereafter, as the leaves age, portions of the darker green areas turn deeper green and then greenish-purple, while the lighter green areas turn medium and light yellow and some of the latter areas then turn reddish. The transition is varied so that it is not uncommon for a single leaf to have at the same time areas of deep green or deep greenish-purple, yellow, green and red. As the leaves age still more, the dark green-purple areas turn into deeper purple, the light green disappears, and the leaf is then green-purple with red and yellowish or tannish areas. Since the new leaves at the top of the tree . . . commence their color change later than the older leaves, the tree at certain stages will have some essentially two-color leaves at the top, three-color leaves near the top and lower, three and four-color leaves in the middle zone and lower areas, and two and three-color leaves near the bottom . . . while the darker areas of a leaf are

sharply delineated, and the lines delineating the darker areas do not shift, and thus the relative sizes of the darker and lighter areas remain constant, each area increases in absolute size during the growth of the leaf. The various color zones of the lighter area are not sharply delineated from one another, but to the contrary merge into one another and their relative sizes change, some increasing in relative size while others decrease."

The flowers of this cultivar are white, and the plant is said to resemble ordinary *C. florida* in all other respects including vigor. It differs from other variegated-leaved cultivars such as *C. florida* 'Welchii' in pattern and color of variegation, and is said to be much more vigorous in growth. It should be hardy in Zone 5 conditions of the Arnold Arboretum Hardiness Map, and plants are to be tried at the Arnold Arboretum for hardiness under our climatic conditions in Boston.

Cornus kousa 'Summer Stars'

A new cultivar of Kousa Dogwood registered by Mr. William Flemer III, P.O. Box 191, Princeton, New Jersey 08540 for the introducer, Treesearch, P.O. Box 113, Kingston, N.J. 08528.

This originated in 1964 from seed of *Cornus kousa chinensis* grown by Mr. Peter E. Costich, Center Moriches, Long Island, N.Y. *C. kousa* 'Summer Stars' is . . . "characterized by its general similarity to typical varieties of the species *Cornus kousa* but being primarily distinguished by its prolonged and spectacular summer-flowering habit, with flowers retaining their white color and remaining unblemished from about mid-June to late August or mid-September . . . The flowers are about 25% more abundant and about 20% larger in comparison with flowers typical of *C. kousa*, which fade in about two weeks after their normal June 10th to 15th blooming date when grown under the same conditions in the same region of central New Jersey and Southern New York."

C. kousa 'Summer Stars' was first described, without the name, in *Avant Gardener*, Vol. 21, No. 10, p. 73. Plant Patent #3090 has been awarded to Treesearch, and although the plant has not yet been introduced commercially, it will be.

It should be adaptable to moist, but well-drained soils with pH of 5.0 to 6.5 and hardy to Zone 5 of the Arnold Arboretum Hardiness Map.

Fagus sylvatica 'Dawyck Gold'

A new cultivar of European Beech registered by Mr. J. R. P. van Hoey Smith, Arboretum Trompenburg, Groene Wetering

46, Rotterdam, Holland. The original plant, which is now four years old, is a hybrid seedling with *Fagus sylvatica* 'Fastigiata' as the female parent and *F. sylvatica* 'Zlatia' as the male parent. It was selected at the Arboretum Trompenburg in 1970.

Mr. van Hoey Smith states that *F. sylvatica* 'Dawyck Gold' may be distinguished from related cultivars by its pyramidal growth and yellow leaves. It is considered to be as hardy as the parents, with the same adaptability to soils and location (Zone 4 of the Arnold Arboretum Hardiness Map). An article with a further description of the plant is to be published by Mr. van Hoey Smith in the May, 1973 issue of the *Journal of the Royal Horticultural Society.* The plant has not yet been introduced commercially.

Fagus sylvatica 'Dawyck Purple'

A new cultivar of European Beech registered by Mr. J. R. P. van Hoey Smith, Arboretum Trompenburg, Groene Wetering 46, Rotterdam, Holland. The original plant, which is now four years old, is a hybrid seedling with *Fagus sylvatica* 'Fastigiata' as the female parent, and *F. sylvatica* 'Atropunicea' as the male parent. It was selected at the Arboretum Trompenburg in 1970.

Mr. van Hoey Smith states that *F. sylvatica* 'Dawyck Purple' may be distinguished from related cultivars by its pyramidal growth and purple leaves. It is considered to be as hardy as the parents, with the same adaptability to soils and location. (Zone 4 of the Arnold Arboretum Hardiness Map.) An article with a further description of the plant is to be published by Mr. van Hoey Smith in the May, 1973 issue of the *Journal of the Royal Horticultural Society.* The plant has not yet been introduced commercially.

Fagus sylvatica 'Rohan Gold'

A new cultivar of European Beech registered by Mr. J. R. P. van Hoey Smith, Arboretum Trompenburg, Groene Wetering 46, Rotterdam, Holland. The original plant which is now two years old, is a hybrid seedling with *Fagus sylvatica* 'Rohanii' as the female parent and *F. sylvatica* 'Zlatia' as the male parent. It was selected at the Arboretum Trompenburg in 1972.

Mr. van Hoey Smith states that *F. sylvatica* 'Rohan Gold' may be distinguished from related cultivars by its golden cut-leaves. It is considered to be as hardy as its parents with the same adaptability to soils and location. (Zone 4 of the Arnold Arboreum Hardiness Map). An article with a further description of the plant is to be published by Mr. van Hoey Smith in the

May, 1973 issue of the *Journal of the Royal Horticultural Society.* The plant has not yet been introduced commercially.

Fraxinus pennsylvanica var. *lanceolata* 'Honey Shade'

A new cultivar of Green Ash registered by Mr. Roy G. Klehm, Charles Klehm & Son Nursery, 2 East Algonquin Road, Arlington Heights, Ill. 60005.

It is a selection which originated at Rockford Nurseries in 1945 and has been grown and tested at the Klehm nursery for twenty years, but not introduced commercially until this year. Patent is being applied for.

Mr. Klehm states that *F. pennsylvanica* var. *lanceolata* 'Honey Shade' is distinguished by the extreme glossiness of its leaflets, fast growth, and horizontal branching habit. It is hardy to temperatures of $-30°$ F, and has already been grown successfully in Illinois, Minnesota, Indiana, and Oregon. The Arnold Arboretum is to receive plants for trial under east coast conditions.

Gleditsia triacanthos var. *inermis* 'Emerald Lace'

A new variety of Thornless Honeylocust registered by Mr. Peter K. McGill, A. McGill & Son, Fairview, Oregon 97024. This is a seedling selection made by Mr. John H. McIntyre at Fairview, Oregon in June 1970, and is being offered commercially for the first time this year. The original publication of the name is to be found in the 1973 A. McGill & Son price list, under Plant Patent #3260; in the November 15, 1972 issue of *American Nurseryman*, the following description of *Gleditsia triacanthos* var. *inermis* 'Emerald Lace' appears (without the name) . . . "A strong growing habit which makes the trees approximately 20 percent taller than is average for the species in the first year of growth and continuing thereafter, a habit of carrying the leaflets at a more acute angle to the stem in a plane at right angles to the stem than is normal for the species, a twisted form of the leaflets when young and until they mature which gives the leaves a ruffled or rippled appearance, and a distinctive, attractive and darker green leaf color than is average for the species."

Limits of hardiness and adaptability to soils are unknown for this cultivar at present, but the Arnold Arboretum is to receive plants for trial in Boston late this year.

Juniperus 'Hermit'

A new cultivar which is possibly a hybrid between *Juniperus virginiana* and *J. horizontalis* is registered by Dr. Norman E. Pellett, Ornamental Horticulturist, University of Vermont, Burlington, Vt. 05401.

The original plant was found growing on Hermit Island, Maine by Dr. R. B. Livingston, University of Massachusetts, Amherst, Mass., and propagations have been growing for several years at the University of Vermont and the Arnold Arboretum as 'Livingston No. 11'.

Juniperus 'Hermit' is described as . . . "a vigorous, dense, spreading plant (similar to Pfitzer Juniper in habit) with predominantly acicular (juvenile) foliage, green in summer and silvery-purple in winter; of vigorous, compact habit." It is hardy in Zone 5A of the USDA Plant Hardiness Zone Map, but at present its adaptation in colder climates is unknown. Also, it grows vigorously on sandy soils, but other soil tolerances are unknown now.

Plants were released by the University of Vermont to the following commercial growers in 1972: John Vermeulen & Son, Inc., Neshanic Station, N.J. 08853; C. M. Hess, Jr., P.O. Box 332, Cedarville, N.J. 08311; Hoogendorn Nurseries, 408 Turner Road, Middleton, R.I. 02840; Weston Nurseries, Inc., East Main Street, Hopkinton, Mass. 01748; Spring Hill Nursery, Tipp City, Ohio 45371; Plumfield Nurseries, Fremont, Nebraska 68025; and Willis Nursery Co., P.O. Box 530, Ottawa, Kansas 66067.

Juniperus horizontalis 'Livingston'

A new cultivar of Creeping Juniper registered by Dr. Norman E. Pellett, Ornamental Horticulturist, University of Vermont, Burlington, Vt. 05401.

The original plant was found growing on Hermit Island, Maine by Dr. R. B. Livingston, University of Massachusetts, Amherst, Mass., and propagations have been growing for several years at the University of Vermont and the Arnold Arboretum as 'Livingston No. 7 '.

Juniperus horizontalis 'Livingston' is described as a . . . "Procumbent plant generally 6–8″ in height; foliage is steel blue in summer and bluish-green in winter; leaves mostly scale-like, minute; occasional fruit light blue with bloom; plant much branched and naturally dense." It is hardy in Zone 5A of the USDA Plant Hardiness Zone Map but at present its adaptation in colder climates or to a wide range of soil types is unknown.

Plants have been distributed through the USDA Plant Introduction Station, Glenn Dale, Md. as PI 306621. In addition, plants were released by the University of Vermont to the following commercial growers in 1972: John Vermeulen & Son, Inc., Neshanic Station, N.J., 08853; C. M. Hess, Jr., P.O. Box 332, Cedarville, N.J. 08311; Hoogendorn Nurseries, 408 Turner Road, Middleton, R.I. 02840; Weston Nurseries, Inc., East Main Street, Hopkinton, Mass. 01748; Spring Hill Nursery, Tipp City, Ohio 45371; Plumfield Nurseries, Fremont, Nebraska 68025; and Willis Nursery Co., P.O. Box 530, Ottawa, Kansas 66067.

Pinus radiata 'El Dorado'

An aneuploid cultivar of Monterey Pine registered by Dr. Leroy C. Johnson, Manager, U.S.D.A. Forest Service, Institute of Forest Genetics, 2480 Carson Road, Placerville, Calif. 95667.

This was grown from seed in 1960 by Dr. Margot Frode who studied natural variation in Monterey pine as a graduate student at the University of California at Davis. The seed parent was located one mile N.W. of Cambria, San Luis Obispo County, California. The aberrant plant occurred among 285 potted seedlings obtained from 53 parent trees. After 10 months of growth, it was 4.5 cm. tall compared to an average height of 16.7 cm. for five siblings from the same seed parent.

Pinus radiata 'El Dorado' is described as being of slow growth, compact form, and with extremely dense foliage, $2N=25$. Original publication of the name (which when translated means "Gilded One") with a description and photographs, is to be found in the *Journal of Heredity* 63(5): 293–296 (1972). The plant has withstood very hot summer conditions (maximum 40° C) and relatively cold winters (minimum 7° C), but is not expected to grow under our conditions in the northeast. Unfortunately, it is susceptible to the Western Gall Rust (*Peridermium harknessii*).

Prunus caroliniana 'Crisfield Dwarf'

A new cultivar of Carolina Laurelcherry registered by Mr. George F. Crisfield, 10 Rockwell Avenue, S., Savannah, Ga. 31406.

The original plant was found growing as a seedling in a dense growth of azaleas, vines, and other laurelcherry seedlings on Mr. Crisfield's property in Savannah, Georgia, in March 1969. Mr. Crisfield has taken cuttings from the plant and will continue to propagate for interested growers in his area.

Prunus caroliniana 'Crisfield Dwarf' is described as being a true dwarf. Plants are only one-third as high as the native *P. caroliniana* of the same age, and the leaves are longer and more lanceolate. New branches emerge from the base of the trunk as well as new growth from terminal buds. The leaves are alternate, as with normal *P. caroliniana*, and evergreen. It will withstand either a sunny or shady location, and favors sandy, well-drained soil. Information about hardiness is limited at present, but Mr. Crisfield's plants have not been damaged by temperatures in the upper teens.

Quercus macranthera × *frainetto* 'Macon'

A hybrid oak which has been registered by Mr. J. R. P. van Hoey Smith, Arboretum Trompenburg, Groene Wetering 46, Rotterdam, Holland.

The original plant is now fifteen years old, and is a seedling from *Quercus macranthera* with *Q. frainetto* as the male parent. It originated at the Arboretum Trompenburg in 1958.

Mr. van Hoey Smith states that *Quercus macranthera* × *frainetto* 'Macon' has leaves which are intermediate in form between the two parents. The buds and indumentum of the young shoots resemble *Q. macranthera*. It is considered to have the same hardiness as the parents, which should make this new cultivar adaptable to Zone 5 conditions of the Arnold Arboretum Hardiness Map. An article with a further description of the plant is to be published by Mr. van Hoey Smith in the May, 1973 issue of the *Journal of the Royal Horticultural Society*. The plant has not yet been introduced commercially.

Quercus pontica × *dentata* 'Pondaim'

A hybrid oak which has been registered by Mr. J. R. P. van Hoey Smith, Arboretum Trompenberg, Groene Wetering 46, Rotterdam, Holland.

The original plant is now ten years old, and is a seedling from *Quercus pontica* with *Q. dentata* as the male parent. It originated at the Arboretum Trompenberg in 1963.

Mr. van Hoey Smith states that *Q. pontica* × *dentata* 'Pondaim' may be described as having leaves which are intermediate between the parents. It is considered to have the same hardiness as the parents, which should make this new cultivar adaptable to Zone 5 conditions of the Arnold Arboretum Hardiness Map. An article with a further description of the plant is to be published by Mr. van Hoey Smith in the May, 1973 issue of the *Journal of the Royal Horticultural Society*. The plant has

not yet been introduced commercially. This, and the preceding cultivar, along with the three *Fagus* cultivars mentioned above, are not presently being grown in the U.S.A. The Arnold Arboretum is making arrangements with Mr. van Hoey Smith to import them all for representation in our living collections.

Thuja occidentalis 'Watnong Gold'

A new cultivar of Eastern Arborvitae registered by Mr. Donald P. Smith, Watnong Nursery, Morris Plains, N.J. 07950.

It originated at Watnong Nursery in 1964 as a sport of *Thuja occidentalis* 'Ellwangeriana Aurea Nana', and the original publication of the name is to be found in the Watnong Nursery plant list 1968–1970, where it was first offered commercially.

Mr. Smith states that . . . "This plant grows one foot per year, making a tall slender golden Arborvitae. It differs in that it retains good winter color and develops into a compact well-clothed plant." Hardiness should be the same as the parent, or Zone 5 of the Arnold Arboretum Hardiness Map. The Smiths, who are generous benefactors of our collections at the Arnold Arboretum, have sent young plants for trial under our conditions.

Tillia cordata 'Fairview'

A new cultivar of Littleleaf Linden registered by Mr. Peter K. McGill, A. McGill and Son, Fairview, Oregon 97024. It was selected in June, 1969 by Mr. John H. McIntyre at Fairview, Oregon as a seedling of *Tilia cordata* and bears the Plant Patent #3259.

The name was first published in the A. McGill & Son price list for 1973 where it was first offered commercially. In the Plant Patent column of the November 15, 1972 issue of *American Nurseryman, Tilia cordata* 'Fairview' is described (without the name) as . . . "Characterized particularly as to novelty by the unique combination of a strong growing habit, a larger leaf size than is normal, . . . a heavier than normal leaf thickness, and a distinctive, attractive and darker than normal leaf color."

Information on hardiness and adaptability is lacking at present but it is presumed to be the same as for the parent.

Tsuga canadensis 'Bacon Cristate'

A new cultivar of Canadian Hemlock registered by Mr. Donald P. Smith, Watnong Nursery, Morris Plains, N.J. The original plant was discovered in 1925 as a wild seedling growing in

northern New Jersey by Mr. Ralph Bacon. It was introduced commercially by the Don Smiths, and the original publication of the name is to be found in the Watnong Nursery Catalog for 1966.

Mr. Smith states that . . . "*Tsuga canadensis* 'Bacon Cristate' is one of a group of extremely dwarf and cristate hemlock plants. It resembles *T. canadensis* 'Jervis' but is much more cristate and dwarf. The foliage is darker green." Plants of this cultivar are now in the Arnold Arboretum collection which represents numerous forms of *T. canadensis.*

Tsuga canadensis 'Cloud Prune'

A new cultivar of Canadian Hemlock registered by Mr. Donald P. Smith, Watnong Nursery, Morris Plains, N.J. The orignal plant was discovered in 1938 by Mr. William Wallbridge, Short Hills, N.J. as an isolated seedling in Sussex County, N.J. It was introduced commercially by the Don Smiths in 1972, and the original publication of the name is to be found in the Watnong Nursery plant list for 1972.

Mr. Smith states that *Tsuga canadensis* 'Cloud Prune' . . . "was an isolated seedling. Forty-four years after it was collected, the plant is now three feet high and five feet across. It has developed in a pattern suggesting Japanese Cloud Pruning."

The Smiths have donated a plant for our collection at the Arnold Arboretum.

Robert S. Hebb

Community Tree Giveaway

For the past few years, the Arnold Arboretum has been offering its surplus nursery stock to local community parks and gardens. Interested groups qualify simply by their willingness to dig and move the plant material themselves. We try to provide whatever supervision and training is needed along the way to ensure that the plants are transplanted and maintained successfully.

Our first effort along this line began as a somewhat casual response to a request for several trees to plant in a vacant lot which was being developed into a community park. We agreed to provide the plant material as long as people from the neighborhood were willing to dig it up and move it from our nurseries in Weston.

Word spread rapidly through several neighborhoods; by the time we were finished transplanting for the season, over 50

Two women in the midst of digging operations during a tree giveaway at the Case Estates, Weston. Photo: P. Ogilvie.

men, women and children had managed to dig up, transport and replant over 100 trees and shrubs.

Neighborhoods seemed to find these plants useful for a variety of landscaping purposes. Residents of a Cambridge housing project moved an entire row of mature honeysuckle to create an instant hedge. A community-run low-cost housing corporation began a storage nursery of our trees on a vacant lot in Roxbury to be available as needed for community landscaping. A few parks were started on vacant lots; a few neighborhood centers were embellished with a flowering tree or shrub; and probably an occasional tree or two found its way into a private yard despite our stipulation that all our plant material be planted on property open to the public.

Tom Kinahan of the Arnold Arboretum demonstrating how to ball and burlap a young tree. Photo: P. Ogilvie.

In addition to its landscaping aspect, this first plant give-away proved useful to neighborhoods in several less expected ways. As a simple event, it helped some groups to mobilize. The appeal of a tree or two, combined with the effort needed to draw workers together who could transplant the trees, sometimes seemed to provide just what was required to get a group of people moving. As an event it also exposed many people to entirely new experiences, ranging from those of adults who had never used gardening tools before, to a child or two who had never been out to the country before. As an educational process it conveyed useful information and expertise it would be difficult to obtain ordinarily. And in almost every case, it created an unusual involvement between the trees going into a neighborhood, and the people of that neighborhood.

Largely due to this involvement and our own care in trying to demonstrate how to handle and maintain plant material, the prospects of these young trees have been much brighter than one might expect. Few, if any, plants have died due to the shock of transplanting, although a few roughly handled specimens have gone dormant for a month or so. Despite the often rigorous character of the sites (vacant lots, school yards), surprisingly few plants have been harmed.

Since the fate of these trees depends so heavily on a community's real understanding of site characteristics and proper maintenance, in more recent giveaways we have tended to refocus our efforts from moving a volume of plant material to more carefully assessing sites and teaching the processes involved in transplanting and maintaining trees.

In the long run the real value of our program probably lies in its capacity to involve people with plant material and provide an educational experience.

NANCY M. PAGE

Notes from the Arnold Arboretum

Memorial Gifts and Plantings

The Arnold Arboretum, in its very name a memorial, was created with a bequest from the estate of James Arnold of New Bedford, Massachusetts, and has been developed and operates to this day through the generous support of the Friends of the Arnold Arboretum, past and present. Over the years many individuals have requested that their gifts be used as memorial funds to care for the living collections, to acquire special plants for the grounds or books for the library. Funds have been established for special purposes, such as work in plant propagation, plant introduction, memorial lectures, the care of the rhododendrons or dwarf conifers and others. The Arboretum staff welcomes such gifts. The wishes of the donors are accepted and such funds are, in fact, permanent memorials.

Gifts of five thousand dollars or more can be added to the Arboretum endowment as a named capital fund with the income to be used for special purposes. Thus the Arboretum has, today, Fellowships named for Martha Dana Mercer and James R. Jewett; the William Judd Fund for plant propagation; the Irving W. Fraim, and George R. Cooley funds for staff travel and exploration; the Isabel Shaw Fund for the care of the rhododendrons; and the Mary Sargent and Charles Sargent funds to purchase books in special categories for the library, to name but a few, recognizing either the donor or the person to be memorialized.

The Director, or a representative of the Arnold Arboretum, is always willing to discuss the needs of the Arboretum with anyone wishing to establish a named memorial fund. Gifts are accepted by the Trustees of the Arboretum, Harvard University, and are tax deductible.

In the past smaller gifts have been accepted and a memorial plant has been designated by the staff within the collection of the Arnold Arboretum. Such plants are marked with a specially

embossed aluminum label which carries appropriate wording such as "In Memory of ...., the gift of .... 1973". The Memorial label is located on the plant along with the Arnold Arboretum record label which has data important to the staff regarding the plant. The gift and the plant involved are also recorded in our permanent record files. The staff tries to select and locate the plant in accordance with the wishes of the donor. Thus, memorial conifers, crabapples, lilacs, rhododendrons and fringe trees are to be found in the regular collections and in the woods, or near a pond or at a scenic outlook, as requested. The gift is added to the funds available for the general care of the living collections.

The labels chosen are long lasting and not conspicuous or detractive of the beauty of the plant. We regret that we cannot accept specially cast labels or more prominent ones for such labels are vulnerable to damage by defacing, bending, or removal.

An alternative suggestion which has been accepted by some as a memorial is the purchase and designation of a book for the library. The books chosen by the staff carry a special bookplate with the name of the person to be remembered and the donor. We also will accept gifts of books, if needed for our library, bearing the personal bookplate of the owner, to which we add the Arnold Arboretum bookplate and the name of the donor and the date of the gift. The librarian is willing to aid in the selection of appropriate memorial volumes. The books within the excellent library of the Arnold Arboretum have restricted circulation, but the library is available for research and special use by qualified individuals.

The staff is deeply appreciative of the support it receives from the Friends of the Arnold Arboretum and is willing to cooperate in these special ways.

RICHARD A. HOWARD


PLANTED IN MEMORY OF
JOHN DOE
JULY 12, 1907-JAN. 5, 1973


Arnold Arboretum Library
Gift of

Arnoldia Reviews

Wild Wealth. Paul B. Sears, Marion R. Becker, and Frances J. Poetker. New York: Bobbs-Merrill Co. 1971. 322 pages, illustrated. $20.00.

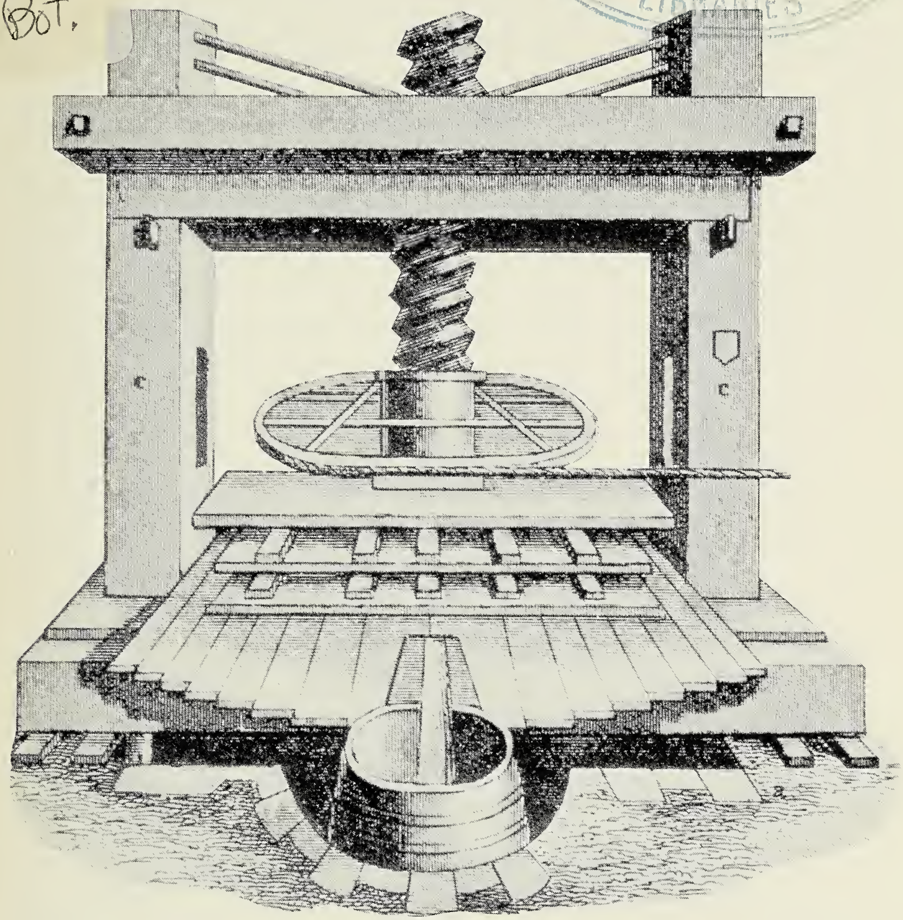
Three contrasting sections by an ecologist (43 pages), a practical gardener-horticulturist (135 pages), and a flower arranger (119 pages) are correlated with over 250 drawings to describe an area near Cincinnati, Ohio and its native and cultivated plants.

Sears' essay is a rambling explanation of the factors of the environment that are present and have produced the growing conditions of southwestern Ohio. Mrs. Becker and her husband have grown an amazing array of plants on eight acres of woodland. Her account of success and failure with each species should be considered the highlight of this book. Regrettably the valuable horticultural suggestions seem to me to be lost in the literary style adopted. Mrs. Poetker's contribution begins with a chapter titled "A different kind of beauty" and then describes the preparations for arranging fresh or dried plant parts in a variety of containers.

The artist, Ms. Forberg, has sketched the arrangements and a description accompanies each indicating the materials and procedures. Subdued color wash gives variety to the illustrations and enhances the attractive layout of the book. The illustrations are mostly impressionistic. While the representations of individual species are recognizable, the plates having several plants present an unnecessary puzzle of "find the plant". Marginal captions throughout the text describe the illustrations and are generally very well written. The compositor set these in italics and then, annoyingly, has the habit of using the generic name as a common name with an initial capital letter and in the same type; e.g. tradescantias, and several words or lines later refers to T. ohiensis in roman typeface. A very complete index is supplied.

R. A. H.

ARNOLDIA *is a publication of the Arnold Arboretum of Harvard University, Jamaica Plain, Massachusetts, U.S.A.*



ARNOLDIA

The Arnold Arboretum Vol. 33, No. 4 July/August 1973

Contents

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Cover: Steel engraving of an apple press, from the Iconographic Encyclopaedia. *New York, 1851.*

The Decline of the Apple

The development of the apple in this century has been partially a retrogression. Its breeding program has been geared almost completely to the commercial interests. The criteria for selection of new varieties have been an apple that will keep well under refrigeration, an apple that will ship without bruising, an apple of a luscious color that will attract the housewife to buy it from the supermarket bins. That the taste of this selected apple is inferior has been ignored. As a result, sharpness of flavor and variety of flavor are disappearing. The apple is becoming as standardized to mediocrity as the average manufactured product. And as small farms with their own orchards dwindle and the average person is forced to eat only apples bought from commercial growers, the coming generations will scarcely know how a good apple tastes.

This is not to say that all of the old varieties were good. Many of them were as inferior as a Rome Beauty or a Stark's Delicious. But the best ones were of an excellence that has almost disappeared.

As a standard of excellence by which to judge, I would set the Northern Spy as the best apple ever grown in the United States. To bite into the tender flesh of a well-ripened Spy and have its juice ooze around the teeth and its rich tart flavor fill the mouth and its aroma rise up into the nostrils is one of the outstanding experiences of all fruit eating. More than this, the Spy is just as good when cooked as when eaten raw. Baked, in pies, in applesauce, it holds its firmness and its flavor.

I speak of the Northern Spy in the present because it is still being sold, usually at top prices, at the older orchards in the northeast. One can even buy it occasionally in the larger cities, at exorbitant prices. But I doubt that it is being planted much, if at all, in the newer commercial orchards. There is a reason for this. The Northern Spy tree is large, and difficult to keep in shape for picking. It is sometimes an erratic bearer, and the fruit is very susceptible to a wire worm, which writes tiny scrolls of brown through the flesh and gives it a bitter taste.

The Northern Spy is purely an American apple. It originated

as a chance seedling at East Bloomfield, N.Y., about 1800. By 1840 it had begun to attract general attention throughout the northeast. No one seems to know what ancestry lies behind it.

It is typical of the breeding programs of this century that in some orchards the Northern Spy has been replaced by the Red Northern Spy, which has a more brilliant red skin than the Northern Spy and is therefore more likely to attract attention for sale. But in taste the Red Northern Spy is only a shadow of the old Northern Spy.

My other standard of excellence has almost disappeared. It is the Spitzenburg, originally known as the Esopus Spitzenburg because it originated at Esopus, in Ulster County, N.Y. Its date of origin is not known, but by 1900 throughout New York State it was considered an old apple. In my childhood no farm orchard would be without one Spitzenburg tree, as beautiful in fruit in October as when in blossom in May.

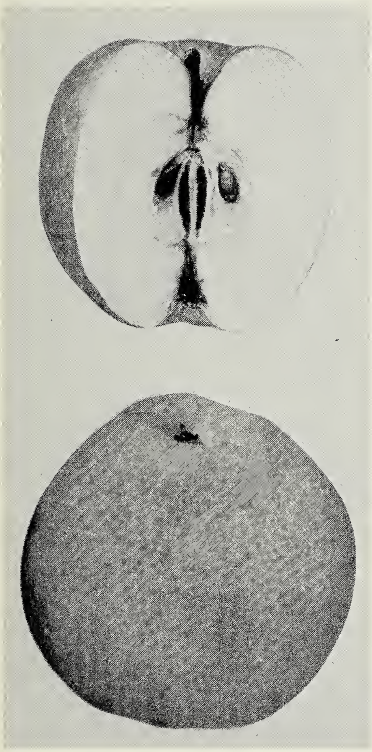
The fruit is of medium size, semi-conic in shape but not long, and somewhat ribbed. The skin is a deep, rich yellow verging into bright red; at its best, completely flaming red marked by pale yellow dots. The flesh is tinged with yellow, firm, crisp, tender, aromatic, not quite as juicy as the Northern Spy. But the taste is unique, as good in its way as the Spy. And like the Spy it is as good cooked as when eaten raw. It was always considered the supreme apple for baking.

A few commercial orchards still have an old tree or two tucked away in a corner. Some twenty years ago, when I was in my fifties, I went to one of these orchards to get some Spitzenburg scions for grafting. The owner of the orchard turned me over to his father, whom I judged to be in his eighties, to show me the tree. On the way I tried to make conversation by saying I thought the Spitzenburg a pretty good apple. Whereupon the old gentlemen stopped, turned in his tracks, looked at me severely, and said, "Young man, the Spitzenburg is the best apple God ever invented."

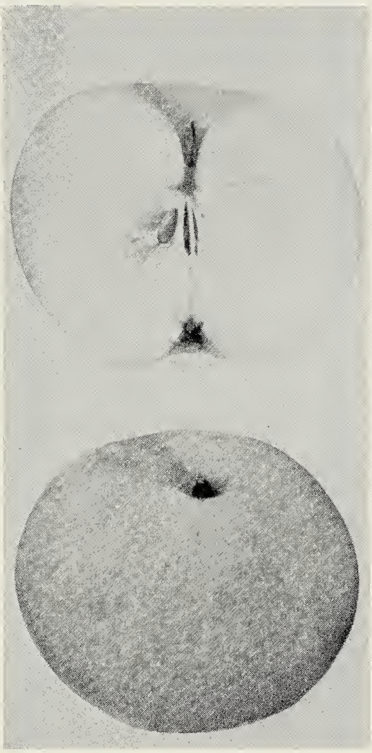
In recent years I have heard of no new plantings. One seedling of the Spitzenburg, the Jonathan, not as inferior to the Spitzenburg as the Red Spy is to the Northern Spy, is still being planted in at least one orchard for use in commercial applesauce. But the Spitzenburg itself is too good to be lost. Its gene source should be used for breeding.

One variety, older than either the Spy or the Spitzenburg, has managed to hold a small place in commercial orchards. It is the Rhode Island Greening, more commonly called the Greening. It originated in the 1700's in Rhode Island, near Newport,

Jonathan



Esopus Spitzenburg



Rhode Island Greening

at a place known as Green's End, where a Mr. Green kept a tavern and raised apple trees from seed. The fruit of the original tree was occasionally given to visitors at the tavern, and the visitors who came back in succeeding springs asking for grafts from the tree started the Greening on its two centuries of success. Its fame soon spread throughout the northeast. It is a long-lived and sturdy, wide-spreading tree. One tree cut down in 1903 was known to be nearly 200 years old.

The fruit is large; the skin, grass green varying to dull yellow, sometimes with a cinnamon blush on the sun side. It is an inferior apple to eat raw, but in many households in the northeast it still reigns supreme as a cooking apple. Less tart than either the Spy or the Spitzenburg, it has a unique mellow flavor that any apple fancier can detect at once in a pie or in applesauce.

Other old varieties have disappeared completely. I doubt that one can now find a Russet, except in an arboretum of old varieties of apples. Yet the Russet was once one of the commonest varieties. A smaller apple, dull green with russet flaking on its skin, rock hard until midwinter, it was actually a mediocre apple both for eating raw and for cooking. Its virtue lay in its keeping ability. In the days before refrigeration it was one of the apples that could be shipped long distances. With modern shipping under refrigeration that quality was no longer as important, and the Russet disappeared.

The Red Astrachan is another important apple that has almost disappeared with the demise of the home orchard and the reliance upon commercial plantings. Once again, no farm orchard of my childhood would have been without a Red Astrachan tree. It is a Russian apple, imported first to Sweden, thence to England, and thence before 1835 into the United States by the Massachusetts Horticultural Society from the London Horticultural Society. It is one of the early ripening apples known as "harvest apples", and the most important of this group. In central New York State it ripens about the middle of August, sometimes earlier. It has no keeping ability. Two days after it is ripe it begins to deteriorate unless put under refrigeration. A medium-sized apple with a fiery red skin and much too tart for eating raw, it vies with the Spitzenburg and the Greening for cooking. Of all apples, it makes the best jelly or marmalade. Both in jelly and in applesauce made by cooking with the skin and straining, the red color of the skin comes through as a bright pink in the finished product. Its flavor both in pies and in applesauce is as good as one can find. Its lack of keeping ability makes it a complete loss for the modern commercial markets,

but it remains a most valuable variety for anybody with a home orchard. It can be kept under refrigeration over the winter, but it must be used immediately when brought into warmth. I know one home owner who puts a couple of bushels in refrigeration each summer simply for the joy of having Red Astrachan pie and applesauce the next spring; its freshly made applesauce, when canned, will hold its taste for a year with little deterioration.

The tree is unfortunately a biennial bearer, but there are two varieties extant, completely similar except for the fact that their bearing years alternate with each other so that with sufficient room one can have a tree of each and have Red Astrachans every summer.

All of the harvest apples are disappearing as home orchards disappear. Commercially they are valueless, since once ripe they will not keep long enough to be displayed anywhere except on an orchard's roadside stand. But in the days before refrigeration, when the winter apples had gone by the next May, they were an important summer delight. And even now their loss means the loss of the flavor of a fresh apple in midsummer, for the refrigerated apples now sold in midsummer are flat to the taste.

The earliest of the harvest apples was the Yellow Transparent, which sometimes began to ripen by the Fourth of July. It was another Russian apple, this one imported directly from Russia by the USDA in 1870. It is a medium-sized, butter yellow apple, juicy and pleasant to the taste, but quickly becoming mushy and dry. For cooking it is not sufficiently tart and holds no form. The tree, however, is an annual and heavy bearer. It is still available at some fruit nurseries.

A better variety in our area was a slightly larger and whiter apple known locally as White Transparent. I have been unable to trace this, unless it is the variety called Early Harvest in Beach's *Apples of New York*. If so it was an American apple, and was in 1903 already over 100 years old. Its liability was that it was a biennial bearer.

One of the common harvest apples, the Sweet Bough, belonged also to that group known as "sweet apples". The sweet apples are all, as the name implies, without tartness, and though many of them are fine for eating raw, they are valueless for applesauce or pies. They were cooked, however, by quartering, coring, and then boiling them with plenty of sugar, either with or without the skins, for an hour or two over a low flame. Cooked so, they made a fine, sweet dessert.

I have not seen a Sweet Bough for years, though I think I have seen a listing of it in a nursery catalogue. It was, as I remember it, a good-sized green apple with a golden tint, and probably its main distinction was in being a sweet apple that ripened so early. It was an American variety, on the scene before 1817.

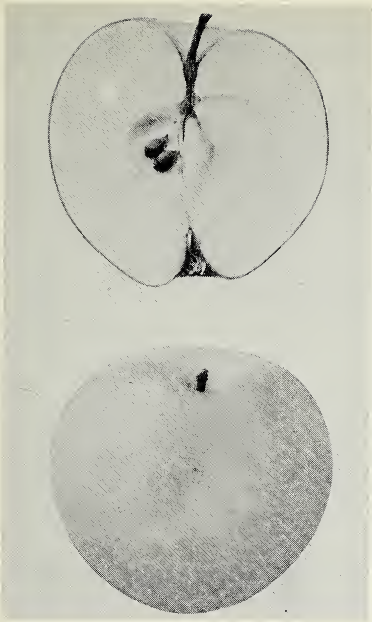
Two other sweet apples used to be common. The Pound Sweet, listed officially as the Pumpkin Sweet, vied among apples for size with the Tompkins King. It is a good eating apple, but it has the unfortunate habit of waterlogging. The flesh of the sections around the core, and sometimes of almost the whole apple, are transformed into a translucent golden green, which however does not seem to change its taste.

The other common sweet apple was the Tolman Sweet, which was a small, butter yellow apple with faint russet dots. Being small it was used not only for boiling but for pickling. And since the tree is very hardy, it was at one time used extensively as a grafting stock.

The Tompkins King, which I have mentioned, is not a sweet apple, but it is the largest apple I have ever seen, specimens often being as big around as the largest grapefruit. It is a showy apple, its skin red with sunlight yellow shining through. Eaten raw it has a pleasant tart taste, not distinctive, and it is not sufficiently tart to be a good cooking apple. As a tree it was considered desirable because its limbs grew out horizontally and needed little pruning; also it is a good annual bearer. It originated as a seedling in northern New Jersey, but a graft of it was given to one Jacob Wycoff of Tompkins County, N.Y., who gave it the name of King.

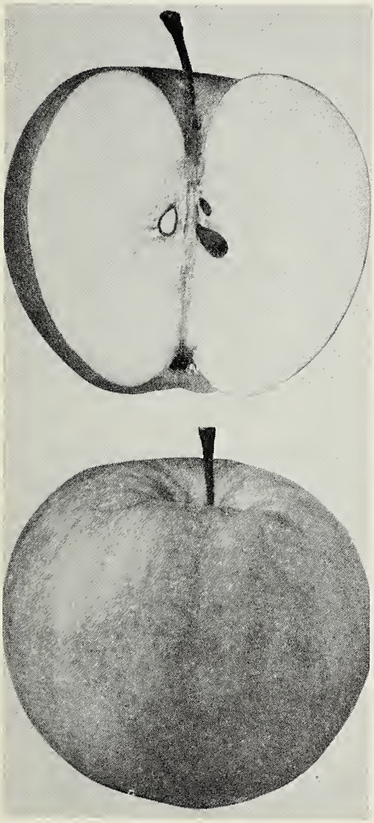
The rise and fall in popularity of certain strains of apples is curious. I have said that the Spitzenburg was considered indispensable for the home orchard of the turn of the century. Another apple of the same strain, the Baldwin, was in 1903 the leading variety in commercial orchards in New York, New England, southern Canada, Michigan, and northern Ohio. It originated shortly after 1740 as a chance seedling on the farm of John Ball, at Wilmington, Mass., near Lowell. It was by no means as good an apple as the Spitzenburg, but it was a larger apple, an easier tree to grow, and as a keeper sufficiently good that it was used for export trade along with the Russet, even before refrigeration.

The fruit is large to very large, the skin tough, light yellow blushed with bright red, with conspicuous gray dots. The prevailing effect is bright red, but darker than the Spitzenburg.



Sweet Bough

Yellow Transparent



Tompkins King

Tolman Sweet

The flesh is yellowish, firm, crisp, and juicy. Though neither raw nor cooked is it as good an apple as the Spitzenburg, it is nevertheless an all around good usable apple. But I think that no variety has disappeared so rapidly and so completely as the Baldwin.

The strain that supplanted it was the Fameuse strain, which had dawdled for 200 years without much success. The Fameuse, more commonly known in the United States as the Snow, was a French apple, of which either a plant or seed was brought to the United States from France in the late 1600's. The Snow is a very small apple; red, with glistening white flesh filled with juice; delicious to eat but of little value for cooking. It was sparingly planted in home orchards. Then sometime before 1870 the strain yielded a chance seedling on the McIntosh homestead in Dundas County, Ontario, and that chance seedling, the McIntosh, was destined to change the commercial production of all the northeastern United States. Its popularity grew slowly at first, and then with a rush. In my childhood there was not a single McIntosh apple tree in the Schoharie Valley of New York, then a high producing apple section. It was, I think, about 1915 that the McIntosh apple first began to appear in the city markets, and once there it became the apple that everybody wanted. Part of its immediate success may have been its novelty to its public, which had not known so beautiful a red apple; one so tender and with so much juice, so good to the taste. It had, and has, its liabilities. In spite of being an apple beautiful to look at and delicious to bite into, its skin is annoyingly tough; it keeps very poorly; and when cooked it goes to complete mush, although good tasting mush. It has managed to hold its own all during the middle of the century. Its place is now being superseded by an apple of the same strain, the Cortland, which keeps and ships better than the McIntosh, but unfortunately has lost the edge of sharp taste which kept the Fameuse strain alive those 200 years.

One variety that as far as I know never reached commercial importance and yet was fairly common in home orchards was the Yellow Bellflower. Locally in central New York it was known as the White Spitzenburg, perhaps because it had the same ribbed semi-conic shape of the Spitzenburg. It may have had an origin from French seed, since the name was sometimes given as Bellefleur, but the original tree, large and old, was in 1817 still standing on a farm in Burlington County, N.J.

The tree is large and vigorous. The fruit, lemon to butter yellow, russet-dotted, sometimes with a pinking cheek, ripens

late, in October; but even then it is not at its best. Of all the old apples, like the Russet it is one of the best keepers, but unlike the Russet, its flavor improves during the keeping, and is at its best after being stored in the cellar until March or April of the next spring. It is then a delicious eating apple, with a mellow taste equal in quality to the taste of a cooked Greening. Neither taste has ever, as far as I know, been duplicated in other apples.

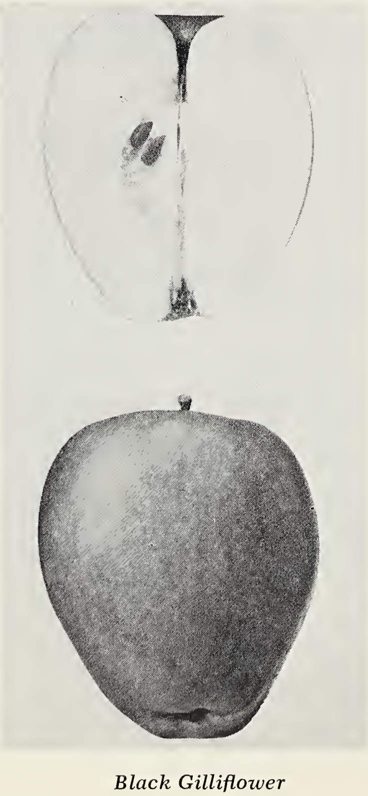
But I speak actually from little knowledge. The 1845 catalogue of the Prince Nursery on Long Island offered 350 varieties of apples, including already the Baldwin. Three hundred and fifty varieties: Think of the different tastes one will never know, the fascinating names of apples never to be tasted; the Fallawater, whose only claim to distinction seems to have been its size, the Black Gilliflower, a long red apple with a pointed nose. Perhaps the Black Gilliflower is the apple I knew as the Sheep's Nose, though our Sheep's Nose was more green than red, with dull reddish streaks, and a solid somewhat mealy flesh. It was probably an ancestor of the modern Red Delicious, for it was as dry to the lips and as insipid to the tongue; its only distinction being its strange shape.

One variety that I have never been able to identify surely was the apple called locally the Pomeroy, though I assume that this was the anglicized version of Pomme Roy, an apple long thought to be French but later believed to have originated in Rhode Island before the Revolution. I remember it only as a pale yellow apple, mild, delicious to eat raw, but the last tree I knew disappeared 60 years ago.

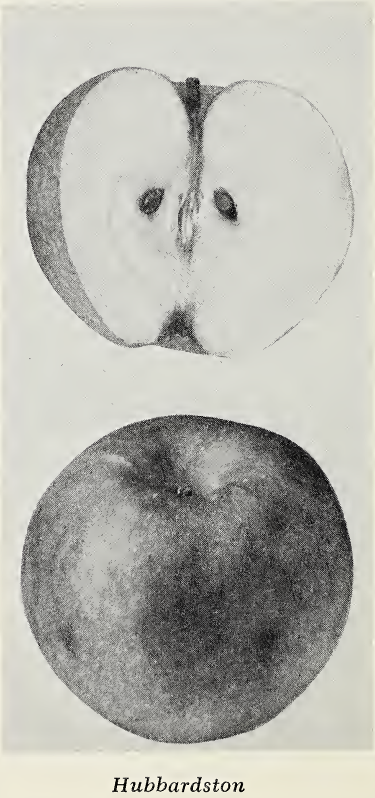
One wonders why certain varieties ever became popular. The Hubbardston, originating in Hubbardston, Mass., before 1832, was never more than a mediocre apple, yet it still lingers in a few orchards. Perhaps the low mark of the old varieties that were once much planted was the Ben Davis; a beautiful apple to look at, brilliant red and shining, but inside dry, coarse, and tasteless. A great many of small commercial orchards got stuck with the Ben Davis, having planted good stands of the new and much touted variety, and brought them to production only to find that buyers bought the fruit one year and never again. There was nothing then to do but tear the trees out and replace with another variety. On the other hand there are, I am sure, many local varieties that still remain popular in their own localities. The Smokehouse is one of these, named from an original tree that grew near a smokehouse on the farm of William Gibbons, Lancaster County, Penna. It is still a popular

Yellow Bellflower

Baldwin



Black Gilliflower



Hubbardston

apple throughout the Pennsylvania Dutch section, but never seems to have been good enough to extend its range.

The sad fact we must face is that, as in pears, we have let the gene pool grow limited. Intensive breeding primarily for commercial purposes, and the disappearance of home orchards may already have limited the possibilities for future development. Unless the apple is going to become a standardized mediocre fruit, the main emphasis on future development should be toward taste. What we need now are apples that will bear annually, keep well, ship well, look beautiful in a supermarket bin, and at the same time taste as good as a Northern Spy or a Spitzenburg. If we cannot do that, then we have failed.

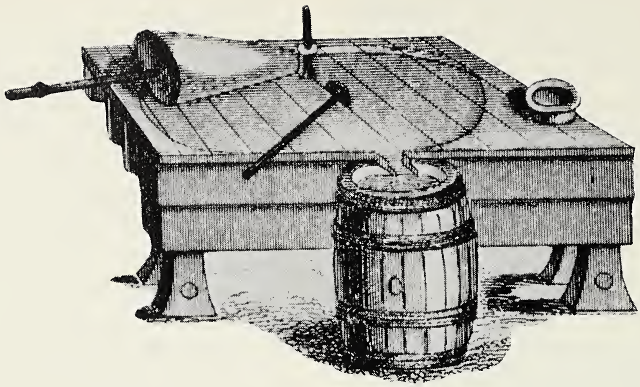
And I must confess that I am equally worried over the modern practices of culture, once again geared only to commerce. Because labor is expensive and an apple grower wants to make money, he keeps down weeds with chemicals, kills the pests with chemicals, thins the fruit with chemicals. All of these go into the soil, thousands of tons of them annually. Who has studied the effect this may have on the soil of the future, on the drainage water of the future, on the water springs of the future, on the health of men in the future? Perhaps the apple growers and the university agronomists had better pay more attention to Rachel Carson

FRED LAPE
Director,
George Landis Arboretum
Esperance, New York

Notes

The best source of information on old varieties of apples is *The Apples of New York* by S. A. Beach, published in Albany, N.Y., in 1905, as Part II of the Annual Report of the New York Agricultural Experimental Station for 1903.

The illustrations in this article are reproduced from Volumes I and II of the above.



Some Afterthoughts on Apples

Apples were grown almost exclusively for cider making until the advent of the temperance movement in the 1830's. Consumed by rich and poor alike, the refreshing beverage also served as currency and from earliest colonial days provided a principal item of export to the southern colonies and the West Indies.

According to U. P. Hedrick, author of *A History of Horticulture in America to 1860*, the product sold as 'cider' was always hard cider; freshly extracted juice was offered as 'sweet apple juice'. Many bought the latter to age according to their individual tastes.

Although the commercial demand for cider declined as a result of the temperance reformation and many orchards were destroyed, interest in home production continued unabated, judging from the lively correspondence to be found on the subject in various early gardeners' journals. Advocates of abstinence branded the golden liquid unsafe, unwholesome, and nonnutritious, while health faddists attributed laudable properties to it in the treatment of such disorders as dyspepsia, biliousness, and even alcoholism.

W. F. Heins of Paterson, N. J., writing in *The Horticulturist* in 1868, had these directions to offer the home brewer:

> A good and pure article of cider requires but little labor in its manufacture. The apples are gathered before they are fully mature, and placed in a cool, dark room . . . for about a week . . . then take two thirds tart and one third sweet apples, rejecting carefully any that have appearance of decay; put them in a tub of water, to free them from dirt . . . then grind to pulp. To avoid particles of fruit getting into the juice, a clean, coarse bag is put into the press to receive the pulp. Fill the receiver with pulp, close the bag, and apply the screw gradually until the juice ceases to run freely. After waiting five minutes, apply strong pressure, and press all out. For barrels, those used for whisky or alcohol answer well . . . The barrels should be placed in an airy and cool cellar, on skids, and are then ready for the juice as fast as it comes from the press. When full, the holes are closed with corks, in which are inserted glass tubes of an inch in diameter, made air-tight at their insertion by sealing-wax. A cup, or other vessel, filled with water, is placed under the free end of the tube, which should be covered by the water at least one and a half inches. Fermentation will soon begin, and violently at first. The water in the cup must be replaced as evaporation takes place . . . to prevent air coming in contact with the liquor in the cask. The tubes are not removed from the casks until the bubbling in the water cups entirely ceases, . . . The nearly clear liquor is then drawn off — carefully avoiding shaking the casks — into new ones . . . filling the casks full. To have a supply, to keep the barrels continually full to the bung, which is a matter of the first importance, some of the cider is put into small casks, turned over, that the contents may cover the bung, to prevent acidity. During the following autumn, about the end of October, the cider is again drawn off into prepared barrels kept always full, and in the following spring it is ready for bottling, and will keep for years.

By contrast, this entry in a late 19th century cook book offers a simple receipt for unfermented cider:

> Cider should be made from ripe apples only, and for this reason, and to prevent fermentation, it is better to make it late in the season. Use only the best-flavored grafted fruit, rejecting all that are decayed or wormy. The best mills crush, not grind, the apples . . . Press and strain juice as it comes from the press through a woollen cloth into a perfectly clean barrel; let stand two or three days if cool, if warm not more than a day; rack once a week for four weeks, put in bottles and cork tightly. Do not put any thing in it to preserve it, as all so-called preservatives are humbugs. Lay the bottles away on their sides in sawdust.

Home cider making is enjoying a modest revival, accompanied by a volume of disparate directions. In the interest of

quality control, one might be well-advised to first consult the USDA Farmers' Bulletin No. 2125 (revised 1972), "Making and Preserving Apple Cider".

Through the joint efforts of the Worcester County Horticultural Society and Old Sturbridge Village, selected old varieties of apples are to be perpetuated in a preservation orchard at the Village. A tract of land has been cleared for the project which was launched officially at dedication ceremonies this spring. Presently about 90 varieties have been planted of stock moved from the Society's North Grafton experimental orchard established 20 years ago by S. Lothrop Davenport, former Secretary of the organization.

The search continues for additional old varieties to expand the collection at Sturbridge. As the trees mature, scion wood and bud sticks from them will be available through the Society to supplement that which they sell from their original orchard. The fruit from the preservation orchard will be sold at Old Sturbridge Village.

For a list of nurseries specializing in under stock of old varieties of apples, consult the Society (30 Elm Street, Worcester, Massachusetts 01608).

JEANNE S. WADLEIGH

The Ralph F. Perry Wood Collection

Mr. Ralph F. Perry

A solitary cabinet stands against the east wall of the lecture room in the Arnold Arboretum's administration building in Jamaica Plain. The one hundred-plus drawers comprising this cabinet are each 1½ inches high, 6½ inches wide, and 13½ inches deep. The drawer fronts attract the eye because each has a distinctive wood pattern, and the total effect of the patterns creates a pleasing design. It also arouses one's curiosity.

In late October of 1972 a group of sixth graders from Quincy visited the Aboretum to do bark rubbings of some trees on the grounds. Each student was equipped with five or six grades of paper and fists full of crayons. Before beginning their endeavors on the grounds, the students were brought by their teacher into the building where they assembled in the lecture room to look at the photographs on the walls, the slide display cases, and, perhaps most importantly, to discover the wooden cabinet.

I happened to be in the room at the time solely to observe the children's discoveries. Investigating the cabinet, they were surprised and pleased to find bark and wood specimens in the drawers. Obviously old enough to have acquired some knowledge about plant names, the youngsters attempted to locate, let us say, an oak, a birch, and a maple specimen.

After the Quincy questers left for the grounds, I sat down in front of the cabinet and selected some of the drawers at random. I studied the wood specimens and the information in each of the drawers I examined. Before I realized it, I was knee deep in drawers and records.

The Ralph F. Perry Wood Collection cabinet is arranged alphabetically by genera; a generic index, common name index (both in lists and charts), and a card catalogue allow for locating particular drawers. The sheer amount of research entailed and the information compiled, let alone the labor and craftsmanship required to organize such a collection, motivated me to learn more about Mr. Perry.

Ralph F. Perry lived in Watertown and was an electrical draftsman for the Cambridge Gas and Electric Company. His job kept him outdoors a good deal as he was present during tree removal at construction sites where he collected specimens of the felled trees.

In the early 1950's after his retirement, Mr. Perry worked constantly on further collections for, and construction of, his wood cabinet and the preparations of the specimens and the information to be contained in each drawer. His hobby demanded long hours, determination, and devotion. His efforts and meticulous work gained him a goodly amount of recognition. He lectured, appeared on television, and established a wood exchange program with people in foreign countries. One arrival, from a contact in Africa, was a shipment of small wooden blocks. Unfortunately, Mr. Perry's health was on the decline at the time, and he was unable to do any extensive research on these blocks. His great-grandchildren use them as toys today.

Even with sorely failing health, Mr. Perry was a perfectionist. By reading a portion of the printed explanation that accompanies the collection, one gains a better understanding of his personality and his execution of the project.

"Let us answer a few questions before you ask them. No dye, stain, filler, or other coloring material of any sort has been used on any of these wood specimens. After careful examination of wood specimens in a dozen of the best museums in the East and consultations with the curator staffs, the method of treatment that leaves them in the most nearly natural color and texture and still assures the least change thru what is called ageing over the passage of years has been chosen.

"After very careful and thoro (sic) sanding to produce a smooth and flat surface all of the specimens in the wood trays have been treated with two coats of the finest quality of clear white shellac, each coat very carefully sanded. That is all. This is the process used by the Furniture Museum, Grand Rapids, Michigan.

"The FRONTS of the trays and the Veneer Panels have re-

ceived the same treatment as above, then three coats of the highest grade, clearest varnish has been applied, the first two carefully rubbed down with very fine sandpaper, the final coat rubbed with pumice stone and water, then with rotten stone and oil, approximating the finish of fine furniture.

"The NAME at the top of the card is the common name most generally accepted; the second line is the botanical or scientific name. Following that is the original home of the tree, the weight of a cubic foot of the wood and its specific gravity, and finally a very short condensed story, giving a description or interesting facts.

"The WEIGHTS and specific gravities, so far as the trays are concerned, are for these individual specimens, computed very accurately by laboratory methods. While they follow fairly well those given by authorities, there are differences; many of them being a little heavier. Every piece of wood here has been seasoned, aged, or cured, whichever you desire to call it, for twelve months or more from the time of cutting, in (a) dry, warm storeroom, before being finished up as specimens. In reweighing it has been found that some of the specimens will gain or lose as much as two per cent in weight with the variations in prevailing humidity. The weights and specific gravities of the Veneers are those credited by the best authorities, because they could not be derived from these very thin pieces.

"The PIECE in the lower left corner of the tray is 'quarter-sawed' and shows the wood perpendicular to the grain; the piece in the lower right is 'slab-sawed' showing the wood parallel to the grain or nearly so. The square immediately below the label is a cross-section; the upper right is the bark, showing that part of the tree that we all may see as it is growing . . ."

Upon examining the collection at the Arboretum, one will discover that each drawer front is a piece of wood of the same type as is found in the tray. This explains the varied tonal pattern of the whole cabinet front. The visitor also can absorb a great deal of information from the cards in the drawers. Each drawer has a portion or all of a 3 x 5 index card glued to the bottom, while all the wood specimens are rivetted to the bottoms of the drawers. Mr. Perry clearly intended his collection to survive any mishandling!

Someone browsing through the cabinet can locate a grass that is used for water pipes, wood that is used for shuttles in textile mills and golf club heads, and note drastic differences between the wood and bark of a street grown Ash (*Fraxinus*) and a park grown Ash. Further looking will reveal a sample of a

tree that grows in salt water, wood that is most prized for musical instruments, and (without opening a drawer!) the foulest smelling wood in the collection.

Other information on the cards includes interesting historical facts. Some, relating to plant names, tell us that *Magnolia, Halesia,* and *Wisteria* were named for the 17th century botanical professor, Pierre Magnol, the English botanist, Stephen Hales, and the 18th century physician and anatomist of Philadelphia, Caspar Wistar, respectively. In addition there are references to trees with significant associations in religious history, those that serve as state trees, and a dozen other items of interest.

Donated by Mr. Perry's family in 1968, the collection of cabinet specimens and the separate collection of wood veneers, are a comprehensive source of historical, sociological, and economic information illustrating the importance of the plant world. Above and beyond that, the cabinet is impressive to look at and a skillful and thorough creation. The Arboretum is most fortunate to have received this gift.

HARMONY C. SPONGBERG

Struggle for Survival

In nature's scheme of things many remarkable designs have been evolved for the dispersal of seeds as they ripen. Fleshy fruits containing seeds which are dependent on birds and animals for dispersal change to a wide range of colors enticing to those responsible for their distribution. The pulp provides food to the vector which in turn carries the seeds about in its digestive system until they are expelled in its droppings. In this way the seeds are scattered about the countryside.

Fruits with seeds which rely on the wind for dispersal undergo changes that prepare them for this manner of dissemination. Weight is reduced and the seed coats and wings harden as water is decreased in their structures. Such fruits are functional in design and illustrate nature's way of getting the seeds away from the parent plant.

Large trees which have produced prodigious numbers of seeds throughout their lives may never reproduce themselves, however. Competition for space in nature is uncompromising and fierce, and existing sites are frequently inhospitable.

In 1954, a south-bound off ramp was cut through a granite mass at the intersection of Routes 128 and 109 in Westwood, Massachusetts. This led to a roadway running between two ledges about 25 feet tall. The following list* shows nine species of woody plants that have germinated and continued to grow in the fissures and on the small shelves of this forbidding location. (Figure #1) Four are subjects whose seeds are normally dispersed by wind, while five are carried by birds.

Wind Dispersal

Acer rubrum (Red Maple)
Betula lenta (Cherry Birch)
Betula populifolia (Gray Birch)
Populus tremuloides (Quaking Aspen)

Bird Dispersal

Juniperus virginiana (Red Cedar)
Malus species (Apple)

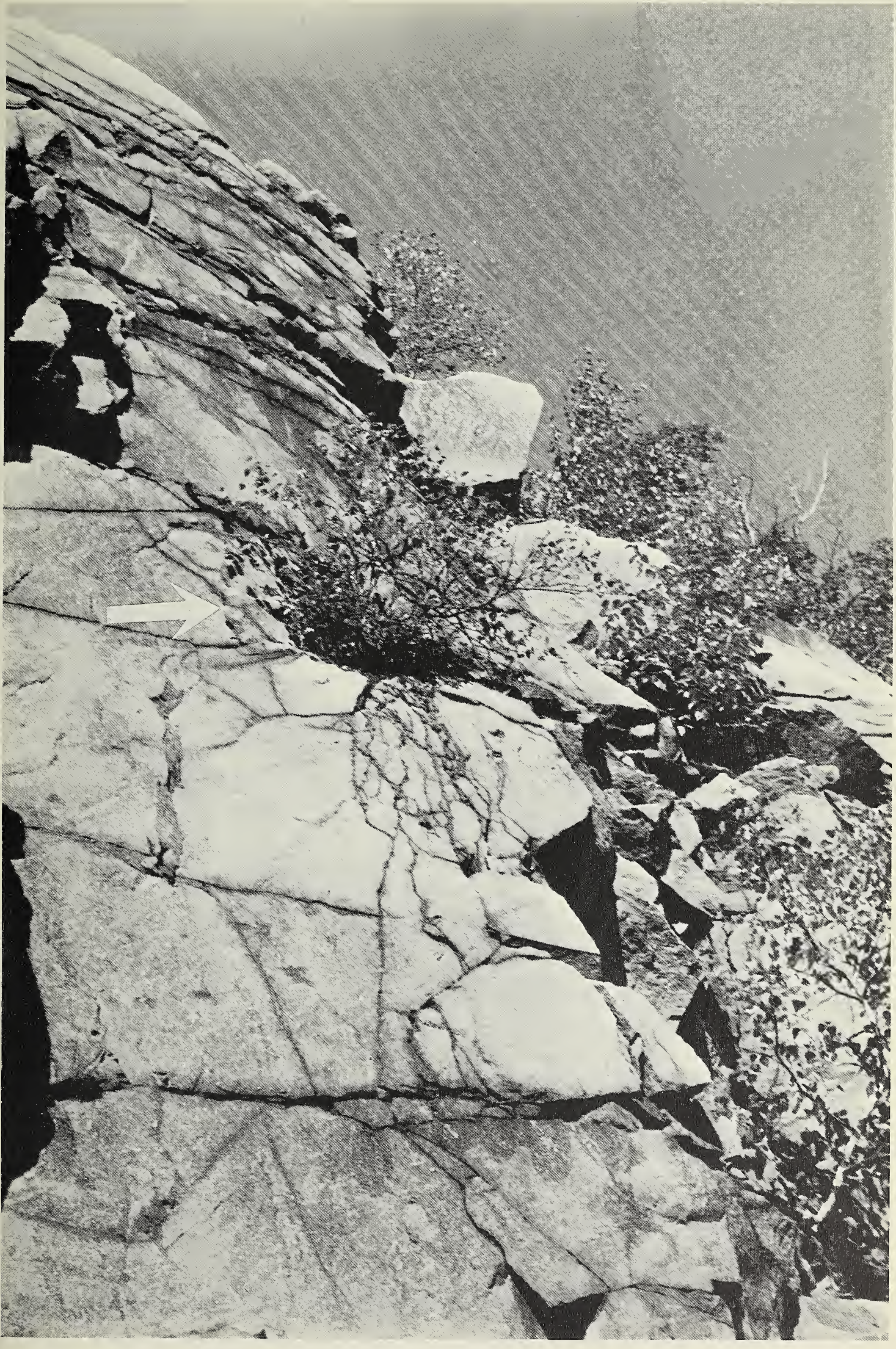


Fig. 1 top left
Fig. 2 bottom left
Fig. 3 above

Sambucus canadensis
Sassafras albidum (Sassafras)
Vaccinium angustifolium (Lowbush blueberry)

Figure #2 — shows birch trees growing in seams of the rock, apparently in the absence of soil. Moisture and nutrients reach the roots by seeping down through the fissures.

Figure #3 — shows a birch tree growing in a small pocket. Decayed vegetable matter has accumulated at its base in sufficient amount to form a growing medium capable of supporting a fruiting plant of lowbush blueberry (*Vaccinium angustifolium*).

The plants on the ledge demonstrate the wide range of temperatures which their roots can tolerate. Stone is a dense medium and one that conducts heat readily. This ledge faces south-east and is of a color that absorbs heat from the sun; during a sunny summer day temperatures in the root areas might well be many degrees above 100° F. Conversely, during periods of cold in winter temperatures in the root zones would approximate those of the surrounding atmosphere and could be many degrees below zero.

ALFRED J. FORDHAM

* Determination verified by Miss Ida Hay of the Arnold Arboretum staff.

The Arboretum's Labels: A Valuable Teaching Aid

The living collections of the Arnold Arboretum are used by visitors for diverse purposes which range from sheer enjoyment to serious study. An understanding of the labeling system can greatly increase the pleasures and benefits to be derived, for we try to keep every shrub and tree accurately identified, and to include such other information as may be pertinent. Sometimes this additional data recalls a tale of adventure harking back to the earliest plant explorations, or attests to a nearly extinct species.

Starting down the meadow road, one is immediately aware of the large metal trunk labels found on most mature trees. These labels provide us with the scientific name (Latin name), common name, and native land of the specimen. The metal stand labels used in the shrub collection, on low shrubs, and in many specialized plantings give the same information.

To understand the Latin nomenclature one must have an idea of how the system of plant classification works. The entire plant kingdom has been divided into distinct groups called families; each of these, in turn is divided into subgroups called genera. A genus often contains many species, and a species may be further differentiated by varietal or cultivar names. A family has some characteristic (or characteristics) which allow it to be separated from all other families. Likewise all genera within a family (and all species within each genus) are differentiated from each other by distinguishing traits.

The working of this step-down classification system is similar to the relationship between the following pairs of words: Tool, saw, and keyhole saw. The general denomination tool refers to a large number of items; in order to be more exact, we refer to a certain type of tools as saws, having a more restricted definition. Finally, we have a keyhole saw, referring to a specific type of saw (or perhaps we will have to be even more exact — a red keyhole saw).

In the same way, the more completely a plant is named, the

more exacting are the characteristics by which it is defined. It is useful to note here the differences between a cultivar and a variety. A variety is a population of plants which occurs naturally in the wild, which is slightly different from the rest of the species but not enough so to be considered a species itself. Cultivars, on the other hand, are plants which come from an individual variant of a species that has been propagated, generally to maintain a particular characteristic. A cultivar name is always enclosed in single quotation marks.

A common name also is often noted on the labels but this is a very inaccurate index since the same plant may have many different names in different countries throughout the world. Paradoxically, the same common name is sometimes given to several different plants. Common names are provided primarily for public interest and play no real part in the Arboretum's work.

If a plant originates from one particular area of the world, occurring naturally in the wild, we try to note this on the label also. For example it is fascinating to observe all the kinds that have come from the Orient and which do so well in our New England climate.

Wooden labels which hang from a branch or limb are placed on smaller trees and most shrubs. There also are plastic engraved labels in several specialized collections. These generally provide the same information as the trunk labels but also may carry additional notations which will help us in knowing a plant more completely. The lilac collection often has notes as 'One of the best early magenta varieties', and the tree peony collection has all the Japanese names translated into English ('Tatioshishi' means 'Lion with a Standing Tail' for example).

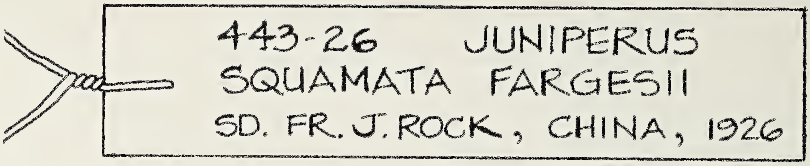
In addition to the various display labels which I have just mentioned, small metal labels are placed on every specimen. These hold the key to understanding the Arboretum's living collection in depth. In the three lines of print that the typewriter-like machine (called an addressograph) can emboss on the zinc tape, we concentrate the accession number and year of accession, scientific name, propagation technique, and source from whence the plant came. Except in the case of large mass plantings of one type of plant, each tree and shrub should have one of these tags; unfortunately this is not always possible what with the ravages of Mother Nature and the increasing amount of vandalism.

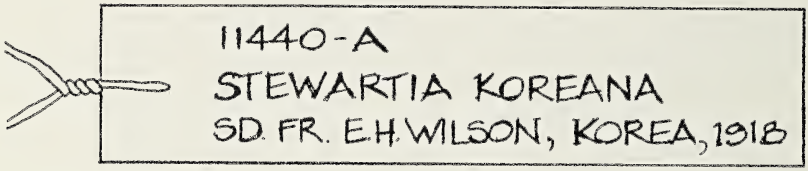
In the collection we do not limit ourselves just to the name of the plant for identification, but have a numbering system

so each can be treated as an individual. Upon arrival at the Arboretum every plant (or seed, cutting, etc.) is given a number which is known as its accession number. For the first 45 years plants were numbered sequentially from 1 (the first plant) to 23000; in 1917 the accessioning system was changed to a number-year unit. Thus the number 443–26 would be the 443rd plant (or group of plants) received in 1926. If more than one plant is covered by the accession number, then the individual plants are designated by letters which come after the number. In the case of the *Stewartia* in the illustration we find that plant 11440-*A* is located in a specific spot on the map 11a, whereas its brother plant 11440-*B* is found elsewhere on the grounds.

Following the scientific name is an abbreviation which tells how the specimen was received, and from this we can tell how it was propagated. The following abbreviations are the most commonly used:

sd .... germinated from seeds
sdlg .... plants collected or received as seedlings
ct or rc .... a rooted cutting
gr or sc .... a grafted plant
rtc or rp .... plants propagated from root cuttings
lyr .... plants propagated by layering
bd. .... plants propagated by budding (a type of grafting)





These notations are important for our field work. The pruners must know if a plant has been grafted, for they need to remove any suckers from below the graft union so that the understock does not take over the named plant. Also any plants that are grown from seeds or seedlings must be checked before they are put on the grounds. This is necessary because a seed may be a hybrid and one often cannot tell until the plant is a good size if it is true to its parent.

Always of interest is the plant's source which also is noted on the tag. The Arboretum receives plants, seeds, and cuttings from other arboreta, nurseries, botanical gardens, and individuals from all over the world, and from expeditions into remote areas by famous explorers like Wilson and Rock. The metal labels shown above, for example, identify plants which were found in the Orient by the Arboretum sponsored expeditions and were the first of their variety in the United States. If a plant is derived from another plant already in the collection, the parent plant's accession number is given. If a plant comes from outside of the U.S., the country of origin is noted on the label.

The entire Arboretum is mapped in detail and when a tree or shrub is planted it is immediately added to the maps. This is not only important for quickly locating a given plant, but also to expedite relabeling when a tag is lost or removed. Since most plants of one family or genus are grouped together on the Arboretum grounds, the laborious job of scientifically identifying the specimen in question is thus eliminated.

One of the most important functions of the Arboretum over


MAGNOLIA SOULANGIANA 'BROZZONI'
VARIETY OF SAUCER MAGNOLIA

the last century has been the introduction of new plants into cultivation in the United States. Many of the most popular and interesting items in the commercial trade were either discovered on plant expeditions or introduced from European or Oriental sources, first into the Arboretum's collections and then to the public. The grounds have many living specimens which were the first of their name to be grown in the United States. The Paperbark Maple, Dove tree, and Silk tree on Bussey Hill are examples of just such individuals. These plants (and all plants that represent Arboretum introductions) are marked with yellow tags that read 'Introduced into the U.S. by the Arnold Arboretum'.

Those students of plant history will be especially interested in any plants with a metal tag that simply says 'Type'. In horticulture and taxonomy the process of designating a plant as a new and distinct entity requires publication of a complete description in the literature (as in *Arnoldia* for example). The individual tree or shrub on which this description is based is called the 'Type Plant'. The Arboretum has many of these specimens and also many accessions that are cuttings from 'Type' plants and therefore carry the same characteristics. Around the Administration Building are located *Magnolia* 'Merrill', *Hamamelis* 'Arnold Promise', *Magnolia stellata* 'Centennial', and *Hamamelis vernalis,* all of which are original 'Type plants'.

After one has obtained all the information from the tags that seems to suit his needs, it also would be wise to step back three or four paces and take a look at the sort of micro-climate in which the specimen has been planted. When plants are moved from the nurseries to the permanent collections they are always placed with an eye toward creating a beautiful display; but at the same time each plant is put in a spot where the horticulturists think it will find positive growing conditions.

An understanding of the Arboretum's labeling system permits a self-guided tour of the living collections, preferably with notebook as well as camera in hand. Each visitor then has the opportunity to increase his knowledge as fully as his interests lead him, for the library, herbarium, and staff members also are available as further resources.

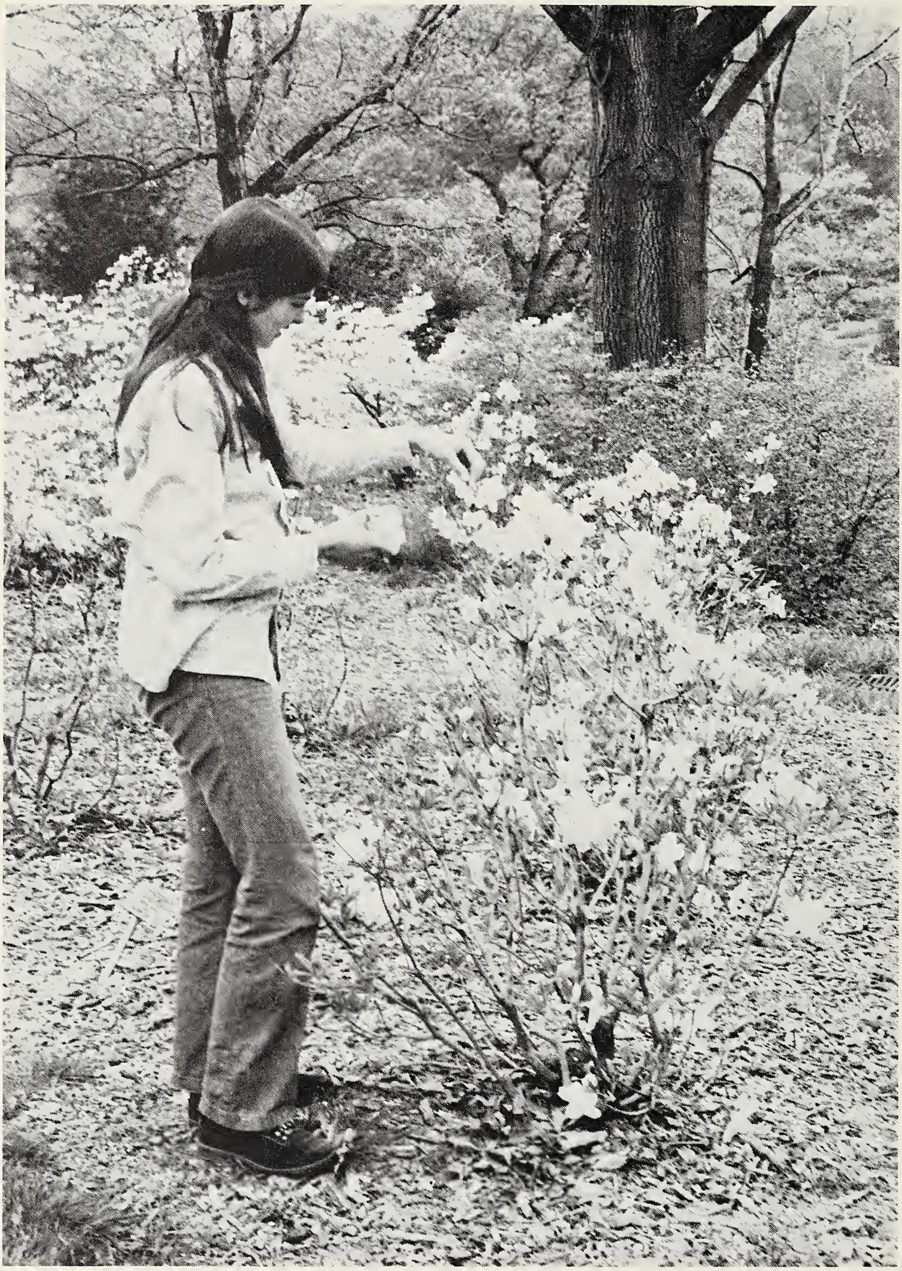
JACK LINK

Aquilegia *Photo: P. Bruns*

News from the Arnold Arboretum

As of January 1, 1974, contributions for regular membership in the Friends of the Arnold Arboretum will be increased to $15.00; other categories of membership will remain the same.

The three issues of *Arnoldia* containing addresses and papers presented during the Centennial Week, May 21–28, 1972 have been assembled in a special commemorative volume just off the press. It is available to Friends of the Arnold Arboretum at $3.00; to others, $3.50.



Curatorial assistant Marilyn Gilmore gathers blossoms of Rhododendron Schlippenbachi *for preservation by pickling. Photo: P. Bruns*

Harry B. Hill planting young trees in the east nursery at the Dana Greenhouses. Photo: P. Bruns

Arnoldia Reviews

Plants for Man. Robert W. Schery. Englewood Cliffs, N.J.: Prentice Hall, Inc. 1972. 657 pages, illustrated. $15.95.

"Man-plant interdependency has existed since his advent. The interest in useful plants has shaped man and his civilization." With such a preface statement Dr. Schery has increased and modernized the coverage of the first edition to encyclopedic proportions and has proven his thesis. Several chapters are small essays on man's relationship with plants as well as his interest in and his use of plants and their parts and products. Material is presented under three primary headings: Products from the Plant Cell Wall, i.e. fibers and wood per se and cellulose compounds; Cell Exudates and Extractions, i.e. latex, tannins, oils and carbohydrates; and Plants and Plant parts used primarily for food and beverages.

Data are given on the origin of many cultivated plants, the varieties that are now cultivated, the areas of cultivation, methods of harvest and the extraction or preparation of the marketed product. Scientific as well as common names are given and the appropriate plant family is indicated. Maps and charts, the latter often flow diagrams of commercial processes, are useful and the illustrations are abundant. A few plates from commercial sources were originally used as colored advertisements and these do not reproduce well and seem out of place in this book. The topics to be covered are so numerous that often lists with abbreviated commentary are used to supplement the data presented on the principal plants of economic importance. A bibliography of additional titles supplements each chapter and references to scientific papers adapted as illustrations or tables accompany the text material permitting further reading or checking.

Plants for Man certainly can be recommended as a text for a course in economic botany and it also should have an appeal as a handy source book for the frequent questions concerning the products of a grocery store. It is indeed the best reference volume with up-to-date coverage now available.

R. A. H.

Fly catcher (Sarracenia flava). *From* Native Flora of the Golden Isles.

Native Flora of the Golden Isles. Gladys Fendig and Esther Stewart. Jesup, Ga.: Sentinel Print. 1970. 147 pages, illustrated. $2.50.

Although the proceeds from the sale of this book are to be used for a worthy cause — the development of the Botanic Garden at the University of Georgia — I can hardly recommend it. Though meant to be an identification guide to the flora of the Sea Islands of Georgia, the drawings are stylized and hardly diagnostic, and a beginner would have a hard time recognizing many of the plants. In addition, the paper is of poor quality and the drawings show through from one side of the leaves to the other. This book is neither beautiful nor useful — a great pity, since the flora it supposedly depicts is an exciting one.

R. E. W.

Flora of the Galápagos Islands. Ira L. Wiggins and Duncan M. Porter. Stanford, Calif.: Stanford University Press. 1971. 998 pages, 96 color photographs, 268 line figures, 170 range maps. $37.50.

This is the first really comprehensive taxonomic coverage of the plant life of the Galápagos. No algae, fungi, bacteria, liverworts or mosses are included; but the flora includes every vascular plant, whether native or introduced, known to occur in these islands. Apparently what does not grow there is as startling as what does. It may not seem too strange that there are no native conifers or members of the rose family but it is odd that native members of the lily or arum families are missing. Perhaps the most puzzling fact is that despite hundreds of miles of tropical shore lines there are no native palms. In fact, there are very few native monocots.

Endemism is very high. About one-third of the species on these islands has originated there. One endemic genus, *Scalesia,* a relative of our sunflowers, holds a position botanically somewhat equivalent to Darwin's finches in the animal world. The several species scattered about most of the islands are of particular interest to students of evolution. Yet the story of *Scalesia helleri* is unfortunately all too familiar. Less than 70 years ago, a visitor noted it "all over the Island". Now the species is confined on the same island to a few plants clinging to crevices on vertical cliffs where goats, these islands' worst enemies, cannot get to them.

It will be unfortunate if this volume is confined to use by only the professional botanist. Anyone, just interested in these "Enchanted Islands", or planning a brief visit will find a very informative introduction in the book. It deals with the history, population changes, economy, physiography, geology, climate, soil zones, vegetation zones, and the history of botanical collections there. In addition to a nine page bibliography, an index to every taxonomic name and a glossary of all technical terms used in the book are included. Most of the excellent drawings are the work of Jeanne R. Janish and the senior author. Each genus represented in the archipelago is illustrated by a line drawing showing all parts of the plant, often accompanied by detailed drawings of one or more parts important in differentiating taxa.

These infinitely strange, unforgettable islands have several things in common. They are all volcanic, isolated, and usually very dry. Most of them suffer from the introduction of once tame domestic animals that have now gone wild. There is little lush and beautiful here. Even Charles Darwin after collecting

plants on several of the islands stated, "All the plants have a wretched, weedy appearance, and I did not see one beautiful flower." *Cordia lutea* with its abundant bright yellow flowers, at least one species of wild cotton, and a morning glory or two could be considered exceptions.

The authors are fully justified in stating that "Darwin found much in the Islands to stimulate theoretical bent. We would hope that this account of the plant life of the Islands will, in some similar fashion, be found challenging beyond its basic purpose."

G. H. P.

Everybody's Ecology. Clay Schoenfeld. South Brunswick and N.Y.: A. S. Barnes Co., Inc. 1971. 316 pages. $7.95.

The title of this book is misleading. The author hails from Wisconsin, works in Wisconsin, vacations in Wisconsin, and writes about his most favorite topic — Wisconsin. Conservation efforts to save the earth from gasping to death are world wide. Ecological problems are not unique to Wisconsin.

Mr. Schoenfeld tells the reader of some of his outdoor adventures that are strangely akin to something one might read in *Field and Stream.* He writes with vivid nostalgia about his favorite boating lake. There is a decided those-were-the-good old-days tone in all these accounts. Pages 210–273 constitute a report from Sammy Squirrel, whom the reader discovers is the "legislative representative" for the Southern Wisconsin (where else!) Alliance of Fur, Fin, and Feathers (SWAFFF).

Despite the above, Mr. Schoenfeld is genuinely concerned about the world and its protection. *Everybody's Ecology* is not a handbook of formulas, answers, and theories; it is a volume of reminiscences, hopes, and fears. Feelings and attitudes are expressed in a bitter, wry, wistful, amusing, and perturbing way.

H. C. S.

Claytonia megarhiza, *alpine spring beauty. From* Rocky Mountain Flora.

Rocky Mountain Flora (Revised Field Edition). William A. Weber. Boulder, Colorado: Colorado Associated University Press. 1972. 438 pages, illustrated. $8.95.

This guide to the flora of the Colorado Front Range is essentially a reprint of the 1967 edition but in a smaller format (so as to be more conveniently used in the field), with the addition of a few colored plates. According to the author, the book is designed to be used by both specialists and amateurs, but I would expect that only quite a serious amateur would find it very effective. The keys, including the one to family, are relatively simple with a minimum of technical terminology and the glossary is well illustrated (although the illustration of a spicate inflorescence in both this and the 1967 edition is drawn with pedicellate flowers). However, since there are no figures of grass inflorescences and their parts, a beginner could not hope to do well in this large group of plants using this guide alone. The line drawings appear to be diagnostic, but there could be more of them, and it is a shame that the plants illustrated by means of colored photographs are duplicated in the drawings.

R. E. W.

Plant Jewels of the High Country. Helen E. Payne. Medford, Ore.: Pine Cone Publishers. 1972. 145 pages, illustrated. $15.00.

In America few plants are better known and loved than the "Hens and Chicks" and various sedums. So it is strange that this is the first book both to be written and published in the United States dealing exclusively with them. Once the gardener discovers that there is more than one kind of sempervivum and more than two or three kinds of sedums the desire to know more about these easily grown, tough plants is great. Helen Payne's book goes a long way in satisfying this wish.

The taxonomic botanist can criticize this book from several standpoints. For example only a few authorities are given for the scientific names that are used. But Mrs. Payne points out that the book is not written for the botanist but for the gardener-grower. The author has been fortunate in being able to rely heavily on Dr. R. T. Clausen of Cornell University for help with sedums. Others are given credit for their assistance.

With an approach that some may find a bit too homey, the author discusses these plants from the standpoints of mythology, supposed curative properties, culture, propagation, hybridization, pests, diseases, and their great variety of uses in gardens. At the end of the book a listing of seven "Public Collections of Sedums and Sempervivums" is given. The Arnold Arboretum collection is the only one listed for New England. This collection is not located in Jamaica Plain however, but is in the small rock garden in a part of the Arboretum known as the Case Estates in the town of Weston. The sizeable collection here of both sempervivums and sedums is mainly the result of extremely generous gifts from Mrs. Payne.

Included in the book are a short bibliography, sources of plant material, 111 color plates, mostly of excellent quality, and descriptions of 187 species, sub-species, varieties and hybrids.

The sempervivum clone 'Elene' is very special to Mrs. Payne. She modestly says, "This sempervivum I named for myself, having neither chick (forgive the pun) nor child to carry on my name . . . This is my one link with posterity." Certainly Mrs. Payne now has a second link — the book, *Plant Jewels of the High Country.*

G. H. P.

Above: Allium schoenophrasum, *chives. Right:* Borago officinalis, *borage. Both from* Gardening With Herbs For Flavor And Fragrance.

Gardening With Herbs For Flavor and Fragrance. Helen Morgenthau Fox. New York: Sterling Publishing Co. 1970. 334 pages, illustrated. $4.50.

Those who sought *Gardening With Herbs For Flavor and Fragrance* when it was out of print will rejoice in its republication. When Mrs. Fox wrote this book in 1933 the "available literature on growing herbs in America consisted of a slender volume and some government pamphlets". To correct this sad situation Mrs. Fox engaged in intelligent, intensive research, and three years of propagation, cultivation and harvesting. Her acknowledgments and bibliography indicate the dedication with which she embraced her work.

Her selection of 68 herbs is explained. Botanical and common names are given. A concise description, history, legend, use and culture of the herbs is recorded. Suggestions are made for the planning and planting of a herb garden. Fifty-six interesting recipes are presented, and Mrs. Fox describes the exacting care with which they were tested, and finally tasted at her own dining table. A chapter on herb teas suggests combinations not generally known, and a section is devoted to recipes for potpourri, sachets and toilet preparations.

For the beginner this book is a wonderful point of departure for herb adventures. For those who must garden vicariously it is a book for refreshment and dreaming.

M. P.

Herbicide Handbook of the Weed Society of America. 2nd edition. George E. Barrier and others. Geneva, N.Y.: W. F. Humphrey Press, Inc. 1970. 368 pages. $4.00.

As stated in the preface to the first edition, "It was thought that a single publication limited to herbicides and dessicants, but containing detailed physical, chemical and toxicological properties, would be of value to researchers, teachers and extension workers in the field of weed research"; also, "information on herbicidal use is kept to a minimum." Thus the practical information as to which material to use, at what strength and when and how to apply it to control specific weeds must be garnered from other sources.

This book is a must for one requiring technical information on weed killers; but I would not recommend it even for the advanced amateur gardener.

R. G. W.

Trees, Shrubs, and Vines: A Pictorial Guide to the Ornamental Woody Plants of the Northern United States Exclusive of Conifers. Arthur T. Viertel. Syracuse: Syracuse University Press. 1970. 593 figures. $3.95.

This guide is inexpensive and quite comprehensive. All the species included are illustrated by means of line drawings, and these are sensibly arranged according to leaf form. Unfortunately, few flowers and fruits are illustrated, and when they are, the drawings are generally poor. The major problem, however, is that the author has included too many species in the difficult groups, and the illustrations are just not adequate to permit identification. Trying to identify species of elms and lindens, for example, from leaf drawings is difficult to say the least, and yet nine of the former and eight of the latter are included. Even consulting the descriptions provided for each species at the back of the book is of little help in these cases. Besides being confusing, this is a waste of space.

R. E. W.

Flowers of the Canyon Country. Stanley L. Welsh (text) and Bill Ratcliffe (photographs). Provo, Utah: Brigham Young University Press. 1971. (ix) 51 pages, illustrated. $3.95.

Neither sufficiently sturdy nor of suitable format, this book is not meant for use in the field. Rather, it is an inexpensive, attractive book to be enjoyed in the home. A total of 101 species is illustrated by means of color photographs which often are both beautiful and diagnostic, although the color is too vibrant in a few cases. The text is interesting and informative. I would recommend this book to anyone who enjoys wildflowers, even if he never intends to visit the Canyon Country.

R. E. W.

Brunnera macrophylla *at the Case Estates. Photo: P. Bruns*

Aquilegia *at the Case Estates. Photo: P. Bruns*

Pulmonaria saccharata *at the Case Estates. Photo: P. Bruns*

Lilies at the Case Estates. Photo: P. Bruns

Method of maintaining fields at the turn of the century in the Arnold Arboretum. Drawing from historical photographs by P. Bruns.

ARNOLDIA *is a publication of the Arnold Arboretum of Harvard University, Jamaica Plain, Massachusetts, U.S.A.*

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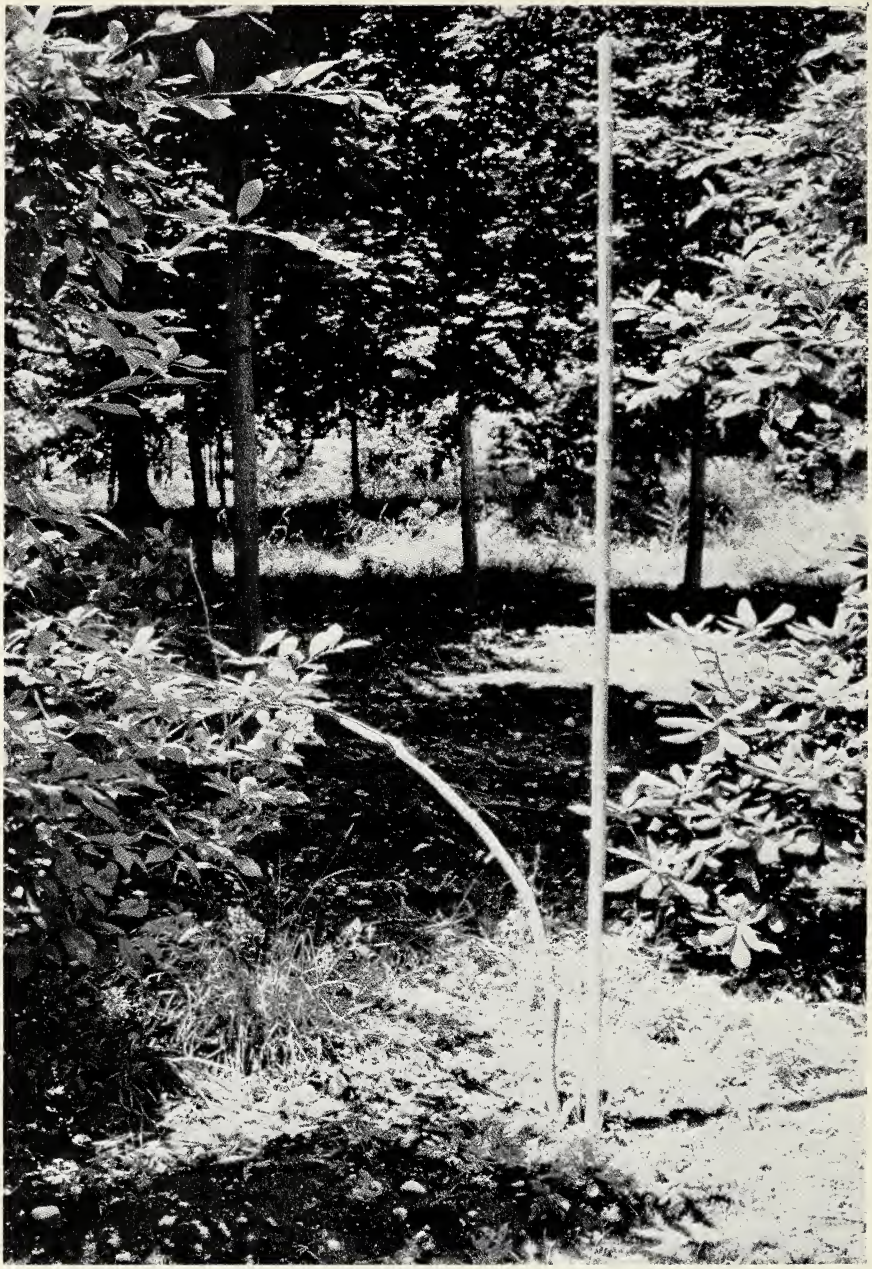
A Guide to Selecting a Strong and Healthy Young Tree

In the wild, the basic structural form of a tree is logically related to the various stresses of its lifelong growing conditions: stem, leafy branches and roots are molded to forms which will best suit the tree's performance in a particular landscape, whether to reach up high for a woodland's diminished sunlight, or to spread out wide into the abundant sunlight and space of an open field.

In a nursery, the basic structural form of a tree is artificially molded by a set of growing practices. Its strength and health and beauty are largely a product of the grower's sensitivity and expertise: how wide he makes his rows and spaces his plants, how frequently he root-prunes or transplants them, how sensitively he trains them, how they are stored and marketed. His techniques may produce a tree far more suited to be grown as a specimen in the average landscape than a tree one would be likely to find in the wild; or they may inadvertently produce a tree which is a structural failure.

The long-range significance of some growing techniques has not been well understood. For instance, research at the University of California at Davis in recent years has demonstrated that the natural capacity of young seedling trees to support themselves even in a high wind can be undermined by severely crowded conditions, or the drastic pruning and staking practiced by some growers. Modifications of the tree's canopy and trunk structure may create an individual which is actually unable to support itself upright when moved out into the landscape (6, 7). Similarly, modifications of a tree's root system through container line production may create permanent structural defects rarely found out in the wild.

Such deformities as these underscore why trees are such a particularly vulnerable form of merchandise; not primarily because they may not have survived poor handling or growing conditions (living things are remarkably adept at finding ways



A tree may be inadvertently modified by growing practices in such a way that it actually can no longer support itself upright, such as this young Tupelo.

to adjust to the most adverse conditions), but because their structural quality and vigor may have been critically diminished through the struggle to survive. And, unfortunately, this kind of damage is not always immediately perceptible.

It is of particular significance with trees, over smaller and shorter-lived plant material, because what initially may be considered a minor structural handicap may become a major structural flaw in time. As a tree matures, the sheer massiveness of its upright bulk generates enormous stresses on every part of its framework. To hold together, and meet the force of environmental stresses successfully, this framework must be strong and healthy.

The stem. According to research at the University of California at Davis, trunks tapering uniformly from base to tip can withstand greater stress from wind and vandals than trunks with little or no taper. While a tapered trunk tends to bend uniformly along its entire length, a trunk with little or no taper bends from the base and is more susceptible to deformation or breakage. Crowding or rigidly staking a tree tends to suppress the normal outward growth of its trunk and the normal trunk taper, while increasing its height (4, 5, 6, 7).

The relationship between the trunk diameter (or "caliper")* and height of a tree is one of the most visible indications of the environment it has come from and the quality of a grower's cultural practices. Trees grown in crowded rows bear the same features as woodland trees: trunks are tall and narrow, branching is concentrated up high towards the only available source of light with lower branches dead or dying from lack of light. Trees which have grown particularly fast from being over-watered and over-fertilized also tend to be taller and lankier than average, but branching is more widely and evenly distributed along the trunk. Those which have grown slowly due to poor soil conditions, girdling roots, or an extremely exposed site tend to have the form characteristic of dwarfed plants: branches and trunk are short and stout, branching is concentrated densely along the stem.

While caliper or height is usually the governing measurement for categorizing the size of a tree, the relationship between height and caliper is so greatly variable that referring to stock

* Caliper of trunk is measured 6 inches above ground level up to, and including, 4-inch caliper size; 12 inches above ground for larger sizes.

solely by one characteristic or the other gives an unreliable indication of the plant's actual size and age.

Accordingly, the American Association of Nurserymen has developed standards useful for indicating a "normal" relationship between key characteristics of several different types of trees. For instance, shade trees are expected to have a rather broad, but definite correlation between height and caliper. Smaller growing trees are expected to have a correlation between number of branches and height, or among height, caliper and number of branches (see Tables I–III).

The canopy. Branching is characteristic of a particular kind of tree and a given site. But in almost all cases the growing tip of a tree should be limited to one dominant ascending shoot (or "leader"), because trees with multiple leaders lose their directed upward growth. Double leaders are apt to have a narrow angle of attachment to the trunk, and as branches form on one side only of each leader and greater pressure is exerted on this weak point of attachment, the tree may eventually split in two.

The proper height above ground of the first permanent branches depends largely on personal taste, the type of tree, and the landscape use it will be put to; and may vary from only a few inches to many feet. But note that the height of a branch will always stay fixed at exactly the same distance from the ground (except for its thickening); in other words, branches do not grow up as the trunk elongates.

There has been a tendency to train a young tree's branches disproportionately high up for its size, particularly in the case of street trees. If a high branching specimen is required, it should be trained gradually. At least some temporary branches should be left on the stem as these branches will both protect and nourish the young trunk, contributing measurably to its caliper growth and taper.

As a result of their findings at Davis, Richard W. Harris and Andrew T. Leiser recommend that one-half or more of the foliage or one-year-old wood be left on the lower two-thirds of the trunk, and half or less on the upper third of the trunk. Besides contributing to the proper growth of the trunk, this distribution will center the wind load acting on a tree at a mechanically desirable point at about two-thirds its total height (6).

If the tree is old enough to have formed permanent branches, their vertical and radial distribution up the trunk should be carefully noted. The major scaffold branches of a tree are best

Overcrowding has produced extreme attenuation of form in 18 ft. tall, 1¾ in. caliper Honeylocusts growing a scant 2½ ft. apart in the row. Note concentration of canopy towards upper one-third of trunk, narrow stem girth in relation to height, dying lower branches. A height of about 10 to 12 ft. would be normal for the caliper of these trees.

distributed symmetrically up the trunk in a configuration that avoids competition for nutrients and light. At least 8 inches and preferably 1½ to 2 feet should be allowed vertically between major scaffold branches; many mature branches lie 4 to 12 feet apart vertically. As a tree matures, closely spaced branches may break more easily than those with wide spacing because close spacing encourages long thin branches to develop with little structural strength (4).

All permanent branches should be attached widely to the trunk, as narrow angles of attachment are weaker and are apt to split with increasing stress as the tree grows.

If a tree has lost its leader, undesirable whorls of branches shortly spaced apart may be formed. Branches lying directly over each other are considered undesirable because they must compete for nutrients and water, and the lower branch is shaded. Two or more vigorous branches at or near the same level of trunk are apt to suppress the leader and limbs growing above. Crossing branches, or branches growing vigorously upright in an otherwise horizontally branching tree will have to be removed to avoid interference.

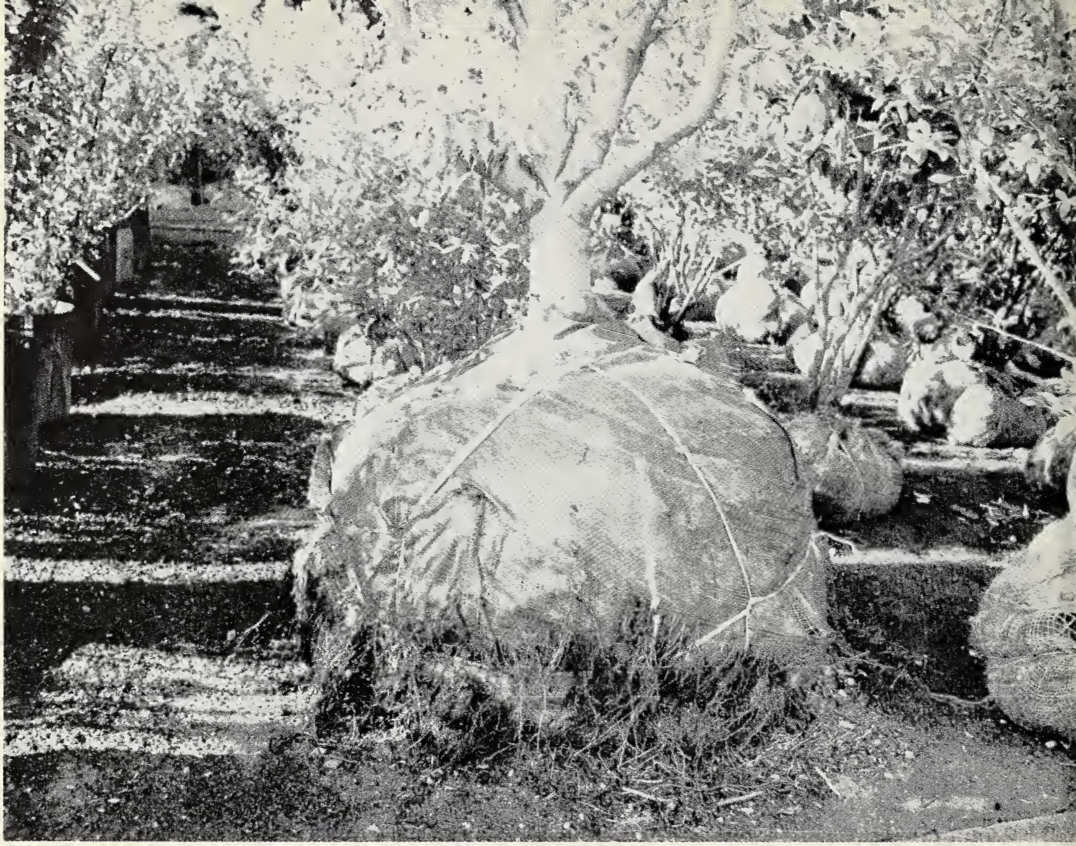
Roots. A particularly vital mechanical and nutritional interrelationship exists between the roots and aerial portions of a tree. But an imbalance between roots and canopy is not uncommon in greenhouse and container production when plants are subjected to an overly intense feeding and watering program which tends to encourage top growth over root growth, and produces a small root system incapable of supporting the canopy and trunk in a more demanding environment without commensurate maintenance (6).

An even more drastic disruption of the nutritional and mechanical balance between aerial parts and roots occurs each time a tree is transplanted. When roots are cut in transplanting not only the physical stability of the tree is affected, since the ratio of above to below ground parts is thrown off, but also its capacity to absorb enough water and minerals from the soil to maintain its disproportionately large aerial structure.

How severe this imbalance is depends on what proportion of the root system remains, how rapidly it can regenerate, and the type of environment in which it is planted. While the growth characteristics of root systems vary by species, and some kinds of trees are innately more difficult to move than others

Right: The two balls in the foreground are "soft" or "homemade" balls, dug up bare root and simply wrapped loosely in burlap and soil afterwards; the root ball lying behind them has the characteristics of a "hard" ball, dug and carefully packaged in burlap to keep the entire ball of roots and soil intact. Root balls should never be left exposed like this to possible injury from heat and drought.

Above: During storage, containers should be as well mulched as root balls to prevent damage to root systems from temperature fluctuations and drought. Note well mulched stock stored to the right and left.



New roots have penetrated lower one-third of burlap on a Cut-leaf Beech apparently over-wintered above ground in a heavy mulch. The absence of new roots on the upper two-thirds of the ball is probably due to root injury from alternate freezing and thawing.

(such as Pawpaw, Hickory, Dove Tree, Walnut, Tupelo, Sassafras, White and Scarlet Oaks), growing practices can exercise a considerable effect on the ease of transplanting.

The development of a root system is influenced by the entire soil environment (soil texture, availability of water and nutrients, soil depth, and competition). A more compact root system is apt to be formed in deep organically rich soil than in sandy soil.

Root systems are also directly and positively modified by the nursery practice of root pruning: an important element of nursery training which should occur every few years as it tends to artificially consolidate a rangy system by encouraging side branching. Trees grown in the wild are particularly difficult

Poorly stored Hawthorns have lost most of their foliage by mid-summer. Burlap has completely disintegrated on the two root balls in the foreground, and the balls are crumbling apart. The other balls are wrapped in plastic which is tightly bound around the base of the trunks with wire — presumably to seal in the moisture and create a "carefree" maintenance system.

to transplant because their roots have never been shortened through pruning.

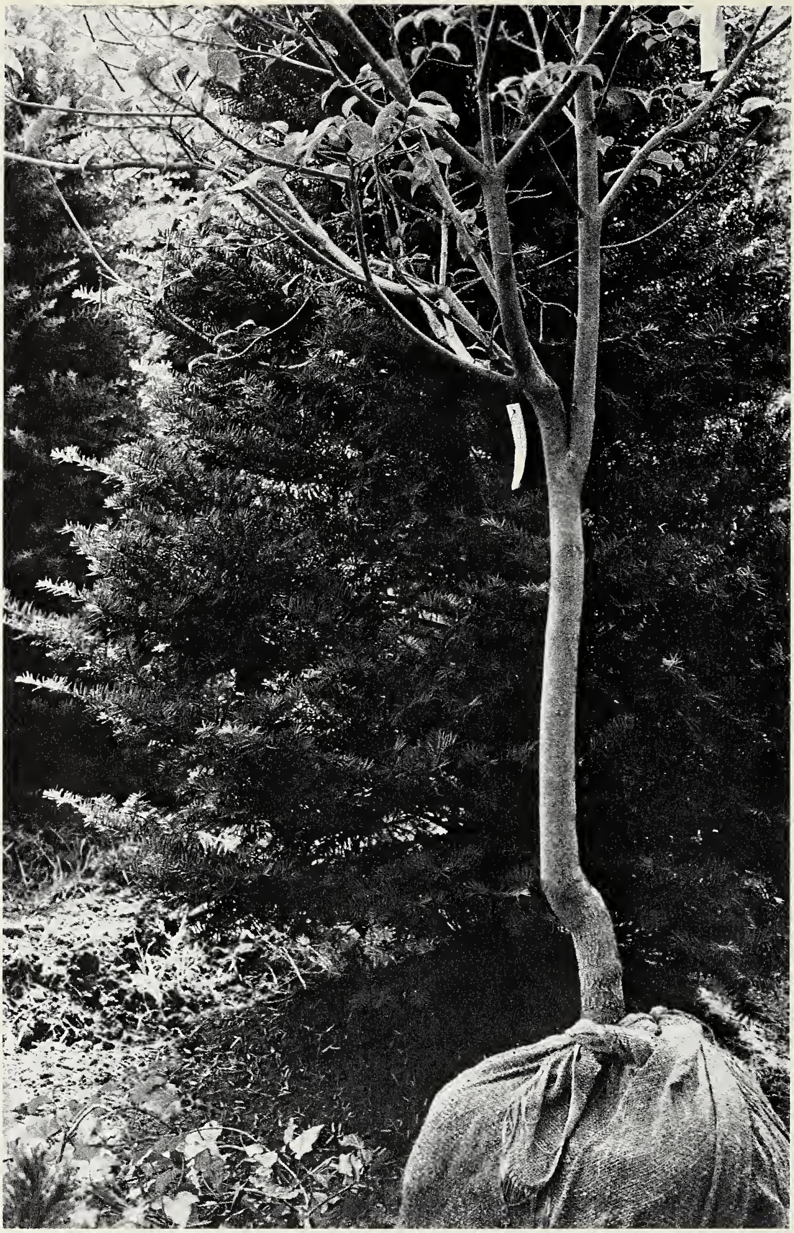
Trees are sold with their roots in containers, or balls of soil wrapped in burlap, or completely bare. Each method has its advantages and disadvantages. Bare root stock and containerized plants are much cheaper than field grown trees which have been carefully balled and burlapped. But trees moved bare root are affected most severely by transplanting since many small feeding roots are damaged when the soil is disturbed, and the root system is more vulnerable to mechanical and climatic damage while being stored and shipped. Normally only trees such as maples, ashes, and honeylocusts, which have demonstrated their relative speed of recovery, are sold bare root; and they are available only in small sizes, during the dormant periods of fall and early spring.

Containerized stock is affected least by the transplanting process; the entire root system can be easily transferred and few of even the small roots are apt to be lost in the process. Nevertheless, containerized stock is sometimes subject to critical root defects, and should be examined closely for damage (see section on Root damage).

Clearly, a tree moved with an intact ball of earth around its roots ("balled and burlapped" or "B&B") will retain more of its small feeding roots than a tree moved bare root, which is why trees reputed to be difficult to move are always transplanted B&B even in small sizes, or grown in containers. In addition, the buffer provided by the soil around the root system tends to protect roots of both containerized and B&B stock while being stored or shipped.

There are several techniques to balling and burlapping a tree's roots; but due to the increasing expense of handling stock, recent practices are tending to become more expedient and less expert. The best method produces a completely intact ball of earth and roots, which is packaged so expertly it is unlikely to shift or come apart during transport and replanting. In recent years nurseries have tended towards the "soft" or "homemade" ball for all but the largest or most difficult material. This alternative is really just a bare root tree wrapped in soil and burlap. Since the original ball of soil has not been retained intact, one might well question whether a homemade ball accomplishes much over the bare root method, aside from buffering the root system a bit from mechanical or climatic injury.

Signs of branch die-back from poor storage.



The major structural framework of this young Dogwood is poor. The kink in the trunk may be left from the point where a competing second leader has been removed later than desirable, as it has already substantially affected the form of both trunk and canopy. Under stress, the weak V-shaped joint where the leader divides into two main branches may split right down the middle.

Another Dogwood with a basic structural flaw. Instead of branching outward from the stem, one of the three major branches of this specimen is growing in against another and will have to be removed — leaving a large hole along one side of tree's silhouette.

The American Association of Nurserymen also provides minimal standards governing the spread of roots in bare root nursery grown shade trees. For instance, a tree of 2 to 2½-inch caliper, approximately 12 to 14 feet high, would be expected to have a minimum root spread of about 28 inches (see Table V).

The amount of stress on roots to provide water for the above ground structure varies according to weather conditions and the relative dormancy of the plant. The hotter the weather and the more fully leafed out the plant, the more water normally passing through its system from roots to leaves. This is why plantsmen prefer to move field grown material in the cool damp periods of early spring and fall when deciduous stock is dormant; however, it is possible to move just about any kind of tree any time of the year if it is done expertly and with a large enough root ball.

To reduce the imbalance between above ground and below ground parts, a newly transplanted tree is usually pruned. If it has been moved bare root, the tree is normally pruned quite severely, with up to a third of its branches removed. While necessary if a tree has been moved roughly, this method of compensation has important disadvantages: the tree may lose several years' past growth in a heavy pruning; pruning the canopy in turn reduces the tree's capacity to produce and store food needed not only for sustenance but also for its new growth; and, of course, balancing the canopy to the roots will in no way diminish the dimensions of the trunk which will remain out of proportion to both of them. If greatly disproportionate, the trunk may even consume most of the food produced by the tree simply to sustain its bulk.

Root damage. Growing practices can be responsible for a series of root deformities which may seriously handicap a tree for life, or even cause its death if left uncorrected (6). Kinked, twisted or circling roots are most commonly found in containerized stock, but also may be observed out in the field if the stock has been raised in containers at some point. These root defects are easily corrected by pruning while the roots are young; but as a tree matures, one may do as much damage by attempting to correct them as by leaving the tree alone.

Improper storage of tree stock also may be responsible for

Girdled root system.

extensive damage to the root system. When roots are raised out of the ground, whether balled and burlapped, containerized or bare root, they become extremely vulnerable to temperature fluctuations, drought, and mechanical injury. Roots on stock stored out of the ground in cold weather may be entirely or partially killed by alternate freezing and thawing. In storage the entire root system should be kept well covered with a thick layer of mulch, and watered regularly.

Two Silver Maples toppled over by the wind. These are actually balled and burlapped trees which were replanted in containers to keep the root systems intact during prolonged storage. When replanted, burlap should have been pulled back from the upper one-third of the ball.

The American Association of Nurserymen provides standards for the relationship between tree caliper and a minimal ball diameter (in the case of shade trees) and between tree height and a minimal ball diameter (in the case of smaller growing trees). For instance, shade trees of approximately 2 to 2½-inch caliper are expected to have a minimal ball diameter of about 2 feet; smaller types of trees of about 6 to 7 feet would be expected to have a minimal ball diameter of about 1½ feet (see Table IV). The American Association of Nurserymen figures are applicable only to stock which has been grown under favorable conditions and which has been properly root pruned. Plants with a coarse or widespreading root system, or those moved out of season, would require a larger ball.

Defective bark on a Dogwood.

A confused whorl of branches with no dominant growing point characterizes the growth response of a tree which has lost its main leader. The Norway Maple on the right, the same age and caliper as that on the left, but with an intact single leader, is a foot or so taller and has the directed upward growth we associate with most shade trees. Note also the vertical distribution of the canopy on these two trees: both have been trained higher than desirable for their present height, with the canopy concentrated along the upper one-third to one-fourth of the trunk. This is not atypical of most shade trees available in the trade, but for the sake of structural strength and nourishment of the trunk it would be preferable to raise the crown more gradually.

A group of young Norway Maples with branching occurring in undesirable whorls. This is a common growth response when the main leader has been pinched back to induce branching.

Indications of health and vigor. A specimen's vigor is indicated by the plumpness of its buds; the size, color and shape of its leaves; the length of last year's growth, as indicated by the length between terminal bud scars; and the rate of callousing over small wounds.

Any signs of branch die-back, or leaf-fall and discoloration should be taken as ample indication of poor health and vigor. Bark should be light and smooth; bark and leaves should be free from all signs of pests and diseases. Young roots should be light colored.

A reputable nursery guarantees its stock for at least one full growing season after transplanting; preferably, it is guaranteed for a complete year. Prospective purchasers would be wise to check the extent of this responsibility in addition to the visible indications of strong and healthy stock.

NANCY M. PAGE

(*All photos by the author.*)

Table I.

Height relationship to caliper for shade trees.
(From *American Standard for Nursery Stock.* 1973)

Caliper	*Average Height Range*	*Maximum Heights*
½ to ¾ in.	5 to 6 ft.	8 ft.
¾ to 1 in.	6 to 8 ft.	10 ft.
1 to 1¼ in.	8 to 10 ft.	11 ft.
1¼ to 1½ in.	8 to 10 ft.	12 ft.
1½ to 1¾ in.	10 to 12 ft.	14 ft.
1¾ to 2 in.	10 to 12 ft.	14 ft.
2 to 2½ in.	12 to 14 ft.	16 ft.
2½ to 3 in.	12 to 14 ft.	16 ft.
3 to 3½ in.	14 to 16 ft.	18 ft.
3½ to 4 in.	14 to 16 ft.	18 ft.
4 to 5 in.	16 to 18 ft.	22 ft.
5 to 6 in.	18 ft. and up	26 ft.

Examples of trees in this category:

Acer rubrum, A. saccharinum
Betula spp.
Fraxinus americana, F. pennsylvanica
Ginkgo biloba
Gleditsia triacanthos
Liriodendron tulipifera
Platanus spp.
Populus spp.
Quercus rubra, Q. macrocarpa, Q. phellos, Q. palustris
Salix spp.

Tilia americana
Ulmus americana

While shade trees of slower growth may not attain the height-caliper relationship indicated above, their heights should not be less than two-thirds the height relationship given above.

Examples of trees in this category:
Aesculus spp.
Celtis spp.
Cladrastis lutea
Fagus sylvatica
Koelreuteria paniculata
Laburnum anagyroides
Liquidambar Styraciflua
Nyssa sylvatica
Quercus alba
Sorbus spp.
Tilia cordata, T. euchlora

Table II.

Height relationship to caliper and branching for small upright trees. (From *American Standard for Nursery Stock.* 1973)

2 to 3 ft.,	5/16	in. caliper,	3 or more branches
3 to 4 ft.,	7/16	in. caliper,	4 or more branches
4 to 5 ft.,	9/16	in. caliper,	5 or more branches
5 to 6 ft.,	11/16	in. caliper,	6 or more branches
6 to 8 ft.,	7/8	in. caliper,	7 or more branches

Examples of trees in this category:
Crataegus spp.
Halesia spp.
Malus spp.
Prunus cerasifera 'Thundercloud'
Prunus serrulata, P. subhirtella
Styrax
Syringa amurensis japonica

Table III.

Height relationship to branching for small spreading trees. (From *American Standard for Nursery Stock.* 1973)

2–3 ft.	4 or more branches
3–4 ft.	5 or more branches
4–5 ft.	7 or more branches
5–6 ft.	8 or more branches
6–8 ft.	8 or more branches

Examples of trees in this category:
Acer palmatum, A. griseum
Cornus spp.
Lagerstromia indica
Magnolia soulangeana, M. stellata
Malus sargentii
Viburnum prunifolium

Table IV.

Relationship between ball size and height or caliper. (From *American Standard for Nursery Stock.* 1973)

*Shade Trees Types 1 and 2 **		*Trees Types 3 and 4 ***	
Caliper Inches	*Minimum Diameter Ball Inches*	*Height Feet*	*Minimum Diameter Ball Inches*
½–¾	12		
¾–1	14	2–3	10
1–1¼	16	3–4	12
1¼–1½	18	4–5	14
1½–1¾	20	5–6	16
1¾–2	22	6–7	18
2–2½	24	7–8	20
2½–3	28	8–9	22
3–3½	32	9–10	24
3½–4	38	10–12	26
4–4½	42		
4½–5	48		
5–5½	54		

* Standard and slow growing shade trees.

** Small upright and small spreading trees.

Table V.

Relationships among root spread, caliper, and height of bare root nursery grown stock. (From *American Standard for Nursery Stock.* 1973)

Caliper	*Average Height Range*	*Minimum Root Spread*
½ to ¾ in.	5 to 6 ft.	12 in.
¾ to 1 in.	6 to 8 ft.	16 in.
1 to 1¼ in.	8 to 10 ft.	18 in.
1¼ to 1½ in.	8 to 10 ft.	20 in.
1½ to 1¾ in.	10 to 12 ft.	22 in.
1¾ to 2 in.	10 to 12 ft.	24 in.
2 to 2½ in.	12 to 14 ft.	28 in.
2½ to 3 in.	12 to 14 ft.	32 in.
3 to 3½ in.	14 to 16 ft.	38 in.

(Tables I through V are reprinted with permission of the American Association of Nurserymen, Inc.)

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Cranberries —
The Last One Hundred Years

Vaccinium macrocarpon. *From* Hortus Kewensis, Vol. II, *by William Aiton*, 1789.

(The following article is excerpted from a talk presented at the Arnold Arboretum during the January 1972 meeting of the Northeastern Section of the American Society for Horticultural Science. Ed.)

It is difficult for us to picture the state of the cranberry industry one hundred years ago. Observing my loss of hair and the graying of what is left I sometimes think I should be able to tell you from personal recollection what it was like. We know, however, that berries were hand-picked by fingers, that foremen saw to it that each picker harvested every berry in his allotted patch and that these were all shipped in wooden barrels of 100 lbs. (or 100 quarts) each. Horse and cart took them to rail terminals where they were stacked four high in the freight car. There was no market for processed cranberries so all were shipped dry except for some packed in water-filled barrels for

steamship transport to the west coast and overseas. I can still remember seeing the last of the hand-picking gangs in the early 1930's; about 160 men, women and children in a long, irregular line across the bog picking into 6-qt. pails and most talking continuously.

Statistics are hard to find for this industry a century ago. Farm operations in general and cranberry production in particular required much hard labor for long hours by many people, all of which may well account for the paucity of records. I think it is perhaps true that my audience may not want a long string of statistics so I will try to review some of the more significant events.

It was just a hundred years ago in 1872 when the Wisconsin cranberry crop exceeded that of Massachusetts for the last time. My source of data refers to the Wisconsin crop as from "the West". It was in 1894 that New Jersey's crop beat that of Massachusetts for the last time. It was not until 1924 that Pacific Coast production reached proportions that merited recording. Since 1949 the records of production in Washington and Oregon are reported separately. It is undoubtedly a blessing that cranberry production appears impractical in California. So five states are, and have been, important in this industry and it is probably significant with respect to Black Monday, November 9, 1959, when the notorious "cancer scare" broke, that the industry could count on support from only 10 of 100 senators. I will say more on this later.

In 1907 cooperative license #1 was granted to the American Cranberry Exchange with the Eatmor brand name. Much as I abhor such a name, this established a trend toward cooperative marketing in cranberries, a trend that has persisted to the present to the great benefit of both cranberry growers and consumers. In 1909 the Cranberry Experiment Station was founded with Dr. H. J. Franklin providing the talent and industry as both chief and Indian. Originally he slept at the Station, the better to work long hours seven days a week. He came to be known as "Mr. Cranberry" and I can vouch he was a most difficult person to follow as head of the Station. Two significant events date from 1913. The first can of Ocean Spray cranberry sauce was produced in that year, and Chester E. Cross was born! The Ocean Spray name began under Marcus L. Urann and was the trade name of his company, the United Cape Cod Cranberry Company. By combining the canning interests of this and others, the canning cooperative, "Cranberry Canners, Inc.", was founded in 1930. Thus the industry came to have

two large cooperatives, one for fresh fruit and one for processing, and while many efforts were made to keep these functioning amicably, there existed great rivalry. Cranberry Canners, Inc. became the National Cranberry Association in the mid-1940's to undertake the cooperative marketing of both fresh and processed cranberries. In the 1950's the National Cranberry Association bought the New England affiliate of the American Cranberry Exchange, and under the new name of Ocean Spray Cranberries, Inc. now markets about 85% of the total U.S. crop.

The cranberry industry's growth in acreage shows a steady increase in Wisconsin, Washington and Oregon, reaching currently to 7,000, 1,250, and 875 acres respectively. In New Jersey the century began with 9,000 acres, increased slowly until after World War I when the false blossom disease struck. From the 1920's to the 1950's many of New Jersey's cranberry bogs were converted to high bush blueberry culture, the cranberry acreage declining to 2,500 acres in 1958. With control of the false blossom disease and a conversion to flood harvesting, New Jersey's acreage is now up to 3,800. In Massachusetts the cranberry bog acreage started this century at 11,300 and now has the same total! It rose to 15,000 in the late 1940's but, as competition increased, marginal bogs (chiefly those with limited water supplies) were abandoned.

It will probably surprise you to know that here "in the land of the free and the home of the brave" the cranberry industry is unlikely to have any further wide fluctuations in acreage. Under a federal marketing order dated August 1, 1968, no cranberries may be sold from new plantings made after the effective date. A similar regulation has been adopted in the chief cranberry-producing provinces in Canada. The present surplus of cranberries was clearly foreseen in 1967, and the national referendum showed nearly unanimous support for the order.

The cranberry industry, therefore, resembles other branches of American agriculture in showing great increases in production efficiency. The success of food production in the U.S.A. may prove to be its bane, for the producer has now become a scattered minority. A newspaper article of last summer projected the present decline of farmers and farm workers (the decade of the 1960's showed a decline of 1.2 million farmers and a decline of 2.8 million farm workers) to the year 1986 when farmers would number near zero. It suggested that the U.S. Department of Agriculture is no longer needed, and the

few remaining farmers could be transferred to the U.S. Department of the Interior where they could be placed on the Endangered Species List and be protected accordingly!

When Dr. Franklin founded the Cranberry Experiment Station in 1909 the average production per acre was 20 bbls. When he retired in 1952 productivity had doubled to average 40 bbls. per acre. The 1970 and 1971 Massachusetts cranberry crops averaged over 90 bbls. per acre, and this State's crop is just under half of total U.S. production. Combining these data with the acreage figures which show 11,300 acres in both 1900 and 1971, the efficiency of Massachusetts cranberry production becomes clear. In my opinion, three cultural improvements are primarily responsible for the increasing production per acre: frost injury prevention, improved harvest technology, and modern control of insect pests.

On September 10–11, 1917, an estimated 50% of the Massachusetts cranberry crop was frozen on the vines just prior to harvest. The very next spring on the night of June 20–21, 1918, an estimated 55% of the coming crop was destroyed. The terrible frost of May 18–19, 1944, came shortly after the widespread winter-killing of the previous winter. Together they reduced the crop about 65% to 159,000 bbls., less than average production back in 1900. On the night of Memorial Day, 1961, a sudden hard frost reduced the crop by one-third, and in that year the Wisconsin crop came within 10,000 bbls. of equalling that of Massachusetts. While these are just the greater frosts, lesser ones occur almost every year. Clearly, such losses cannot be absorbed in a highly-competitive, narrow-profit business.

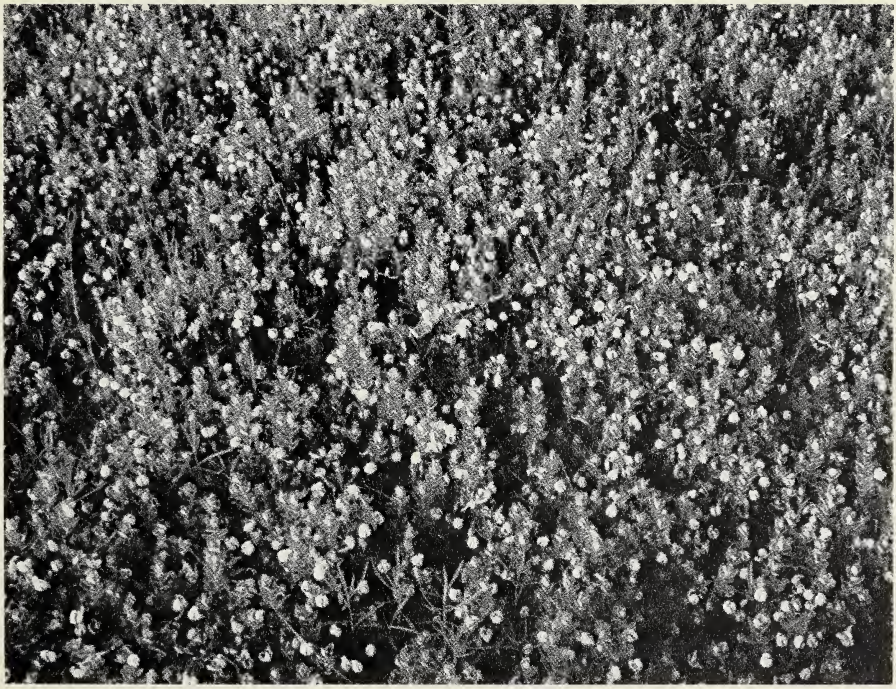
A frost warning system was developed by the Cranberry Experiment Station in cooperation with the U.S. Weather Bureau, which computes twice daily the minimum expected temperature (accuracy 1°–3°F.) and issues a warning by telephone to subscribing growers, and as a public service by radio. With heavy capital outlay growers have supplemented or replaced the slow and sometimes wasteful method of flood frost protection with solid-set, low-gallonage sprinkler systems. These are fully protective about four minutes after starting and continue to protect buds and berries as long as they continue to operate, even though ice forms and coats the vines when ambient temperatures fall below 27°F. Buds, flowers and small green berries are known to tolerate 29.5°F., while under continuous sprinkling at 50 gallons per acre per minute the temperature of plant tissues remains at 30.5°F. or higher. Over 7,000 of Massachusetts' 11,000 acres of cranberries are pro-

tected in this way, using only about 10% of the water required by frost flooding. Cranberry growers here and in other states have impounded vast quantities of fresh water and therefore may be thought of as effective, eager conservationists.

The time-honored method of picking cranberries with the fingers had to be abandoned when the picker could not pick enough berries to equal the value of his time. The wooden or metal-toothed scoop replaced hand-picking in the 1930's, 40's and 50's. It was hard work for knees and back, it was hard on the cranberry vines (some broke off, and the roots of many were pulled up), and some 20 to 35% of the berries was dropped and lost down among the vines. After-harvest flooding retrieved some lost berries as "floats", but costs of clean-up were considerable and the value of such fruit was limited. Right after World War II, and after many unsuccessful attempts, two dry-harvest machines were introduced which late in the 1950's and in the early 1960's came to harvest over 90% of the State's crop. Mechanical damage to the vines was less and the pulling of root systems was almost eliminated by these machines. The efficiency of harvest improved also, so that only 5–20% of the berries was lost. Finally in the late 60's flood harvesting came to Massachusetts and it is certain that this mode of picking, though used on only one-third of the State's bogs, is largely responsible for the two successive record crops of 1970 and 1971. The first national million-barrel crop was raised in 1953, while the first state to raise such a crop is Massachusetts with its 1971 crop of 1,058,000 barrels. It would appear to be appropriate timing that the Massachusetts cranberry industry should produce its first million-barrel crop as the Arnold Arboretum celebrates its centennial year.

Finally, the control of insect pests must take its place in the forefront of the causes of high productivity. The Cranberry Experiment Station was originally founded by an entomologist to find ways of curtailing devastating losses due to insect depredation. As long ago as 1859, B. Eastwood published his book *The Cranberry and its Culture* in which it is clear that two kinds of "worms" cause extensive damage; one to the vines, the other to the fruit. In the effort to find controls for these and a dozen other insect pests, cultural methods like flooding and winter exposure were first thoroughly explored. By 1933 the following insecticides were in regular use: lead arsenate, Paris green, nicotine sulfate, sodium cyanide and pyrethrum. None of these is now used, but I can recall the smelly, hazardous job of dissolving 7 oz. of sodium cyanide in 100 gallons of water and

Above: *Cranberry bog.*
Below: Vaccinium macrocarpon *in flower.*
Photos: M. Gilmore



applying one gallon of solution to each square foot of cranberry bog in the effort to control root grubs, grape anomala and white grub. Here was a dangerous insecticide, men wading around in it with rubber boots and breathing fumes for the 9-hour work day, but I never heard of a casualty. Ground-rig dusters and aircraft made their appearance with the newer organic insecticides. Dragging hoses and the tramp of the booted feet of the spray gang caused much mechanical damage to the vines, so it was not long before helicopters and planes took over pesticide distribution, and refinements in their technique and a conversion to concentrate spraying has made for very efficient control. In the 1960's the installation of sprinklers has led to precision insecticide distribution through these devices, at the same time permitting treatment at dusk when birds and bees are no longer on the bog. The careful grower loses very little to insect pests today and he can do this with only three to five insecticide sprays * a year.

To read from the above you might gather all is well in the cranberry industry with its record crops, its control of pests, its mechanical harvesting, and even its sprinkler weather controls. Such is not the case, and our problems date back to 1959 and the amino-triazole cancer scare. With the nation's newspapers warning people of the hazards of residues on cranberries, the market died. It made no difference that we had a registered and approved use for the weedkiller that would leave no residue on the fruit, it made no difference that we had a fine educational program to instruct growers in the herbicide's proper use. Headlines across the country proclaimed the hazard. Very few Americans know the sequel. By agreement between the White House, growers organizations, U.S.D.A., and U.S.D.H.E.W., the growers, at their own expense but under supervision of H.E.W., tested systematically the unsaleable 1959 cranberry crop; when proved to be free of residue, it was allowed to be dumped and the grower was paid 8.1 cents per pound for his clean fruit. This was the estimated cost of production, and it cost the

* Unlike some commodities, cranberries in Massachusetts are treated only after insect infestations are discovered and quantitated. A prebloom treatment with Diazinon, Carbaryl or Parathion may be needed to control fireworms, cutworms, Sparganothis fruitworm, gypsy moth, tipworm, green spanworm or red mites. Repeated treatments with the same insecticides may be needed in late bloom or post-bloom to control the cranberry fruitworm, second brood fireworms, girdler larvae and weevils. An after-harvest treatment with Dieldrin may be needed once in five years (with drainage flumes closed) to control any of three species of root-eating grubs.

U.S.D.A. nearly $10,000,000 to pay for the residue-free berries that had to be destroyed. It was not until 1963 that a whole crop could be sold again. The industry was accused in the headlines; the efforts at amelioration were relegated to the back pages.

The cranberry crisis occurred three years before the publication of *Silent Spring*, described by Dr. Norman Borlaug as "half-science-half-fiction". Since then environmentalists have been attacking insecticides, and particularly DDT, with misused facts and many fancies. It has been many years since the cranberry industry has made use of DDT, but I was living and working on Cape Cod when the whole Cape was sprayed with DDT in 1949 and the whole of Plymouth County in 1950 for the control of the gypsy moth. I know that the gypsy moth was removed from our list of cranberry insect pests soon after this and that no cranberry bog in either county had to be sprayed for gypsy moth caterpillars for over twelve years. In fact, it was not until 1966 that the gypsy moth again appears on the cranberry insect control chart, and an extension education meeting was called to show the growers what the insect was and what it looked like. Perhaps you can imagine my disgust when I read in the May–June 1971 issue of the Massachusetts Audubon Newsletter in the unsigned article, "Man vs. Gypsy Moth", ". . . The knock-out punch that man counted on was DDT — but it failed. In fact, biologists now say, it actually spread the gypsy moth, making it more annoying". This is pure rubbish, like so much of the environmentalist propaganda.

It is literally true that millions of people are alive today because of DDT, and the U.N. World Health Organization feels it cannot continue its programs for world health improvement without DDT. The U.N. Food and Agriculture Organization feels that tens of millions of the world's people would die of starvation if we had a world ban of DDT. The outcry of the environmentalists has been so loud that it is now doubtful if we could get approval and registration of short-lived alternatives to the chlorinated hydrocarbon insecticides. The food production enterprise in U.S.A. is sorely beset by the very people who know the least about it and who at each mealtime take it all for granted.

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Willow Oak (*Quercus phellos*): A Fenway Jewel

One of the living jewels which studs Boston's "Emerald Necklace" of park systems is a stately specimen of *Quercus phellos*, the Willow Oak. The tree is growing in the Fens near Boylston St., with the Fenway on one side and a steep bank leading to a shelter and the distant river on the other. Sturdy and majestic, the tree stands nearly 60 feet tall with a branch spread equal to its height. Its growth habit represents the best of both the willows and the oaks because its narrow, graceful leaves have a fine, willowlike texture, while its symmetrical rounded crown and dense branching habit give it the nobility of an oak. The 34-inch diameter and mature habit of this specimen imply an age of at least 80 years, so it seems likely this tree was

Above and right: Quercus phellos.
Photos: N. Page

among the original plantings directed by Olmsted when he designed the "Emerald Necklace" in the 1880's.

Quercus phellos is a native North American species, common further south but rare in Massachusetts. It is distributed on the Atlantic coast from New York to Florida, along the Gulf Coast, and north on low sites into Missouri, Kentucky, and Tennessee. Nevertheless, it is hardy as far north as southern New Hampshire. The species generally prefers moist sites such as swamp borders, but will grow under dryer conditions.

The Willow Oak resembles the Pin Oak in a number of ways, and in fact is as widely planted in the south as Pin and Red Oaks are in the north. The tree grows rapidly, suffers from few pests, and has a shallow root system which makes it easy to transplant. The handsome, fine-textured form it develops is often characterized by slender drooping side branches, much like the Pin Oak. If planted more widely, the Willow Oak could provide desirable and interesting variety to the abundance of Pin and Red Oaks now in Boston; the Fenway tree stands as a living testament to the virtues of the species.

MARTHA DAHLEN

(The author, a summer trainee at the Arnold Arboretum, is a student in horticulture at Purdue University.)

Arnoldia Reviews

Echeveria linguaefolia. *From* Echeveria.

Echeveria. Eric Walther. San Francisco: The California Academy of Science. 1972. ix + 426 pages, 16 colored plates and 226 text figures. $15.00.

A beautifully produced book with numerous photographs, diagnostic line drawings, and colored plates, Eric Walther's monograph of the crassulaceous genus *Echeveria* represents the work of over 30 years, during which most of his energies were devoted to the development of the Strybing Arboretum and Botanical Garden in San Francisco's Golden Gate Park. At the

time of Walther's death in 1959, the manuscript of his monograph remained unfinished, but he had arranged with the California Academy of Sciences for his estate to be used to publish the work. Subsequently, the manuscript was edited and prepared for publication by John Thomas Howell with helpful collaboration from Elizabeth McClintock and Reid Moran, the latter a noted specialist in succulent plants.

Although by far the greater portion of the book is devoted to descriptions and keys to 143 species arranged in 14 sections, the introductory portion covers the botanical history, morphology, natural occurrence, and systematic position of the genus. In addition, cultural notes and sections devoted to hybrids and species in cultivation are included. As with most succulents, herbarium specimens of *Echeveria* are difficult to prepare, and diagnostic species characters are often obscured in pressed specimens. It is important to note in this connection that Walther's descriptions were largely based on living materials. Employing the type method of taxonomy, he revisited the type localities of numerous Mexican species to study the plants in nature and to supplement his studies of important herbarium collections.

Certainly most readers of this notice will be familiar with at least a few species of *Echeveria* in cultivation, both as houseplants and as striking ornamentals in warm temperate gardens. For persons wishing to know the identity of their plants, as well as botanists and horticulturalists anxious for more detailed information concerning the species of the genus, Walther's monograph will serve as the standard reference for years to come. It is a pleasure to see a genus of succulent plants (a group that as a general rule is dominated by amaturish coverage in the literature) monographed in a professional manner.

STEPHEN A. SPONGBERG

The Naturalists' Directory (International), 41st edition. South Orange, N.J.: PCL Publications, Inc. 1972. 178 pages. $5.00.

The Naturalists' Directory is an institution of impeccable ancestry and dubious prospects. The current edition lists "more than 3,000 individuals". The edition of 1895 lists 5747. This is not a reflection of decline in the number of naturalists, but rather a decline in the comprehensiveness of the Directory. There is a need for a comprehensive, national and/or worldwide listing of naturalists.

Most of the natural history specialist societies publish lists of members; some of them indicate the specialties of their members, some indicate current research projects of the individual members. There are fairly up-to-date, fairly comprehensive lists of arboreta and botanical gardens both national as well as international. One presumes that comparable lists are available for zoology and geology. If, as alleged, this is a compilation of materials, it is very poorly done.

To be sure, for one who has nothing else, it is better than nothing. However, a publication in its 41st edition ought to do better than this.

Gordon P. DeWolf

Early Gardening Catalogues. John Harvey. London: Phillimore and Co. Ltd. 1972. 182 pages, illustrated. £ 2.25.

John Harvey has written a fascinating book about the early trade in seeds, roots and plants, primarily in England from the Middle Ages until about 1800. It is of importance for American gardeners because such plants were available for American gardens, and tell us something of the way our ancestors gardened.

About one-third of the book is occupied by description text; the balance by reprints of various gardens and dealers' lists ranging from c. 1500–1833.

The one serious criticism one may make about the book is the size of the type. It is too small to be read with comfort by middle-aged eyes.

Gordon P. DeWolf

Forest Environments in Tropical Life Zones. L. R. Holdridge, W. C. Grenke, W. H. Hatheway, T. Liang, and J. A. Tosi, Jr. Elmsford, N.Y.: Pergamon Press. 1971. 747 pages, four pocket maps. $80.00.

This volume, subtitled "A pilot study", is a remarkable documentation of a theory. Holdridge proposed a model for the classification of the world's vegetation into 100 Life Zones arranged on the basis of latitudinal regions, altitudinal regions, and humidity provinces. The system has been applied in some tropical American countries and forms the basis of ecological vegetation maps of El Salvador, Guatemala, Panama, Honduras and Haiti. The present study is a detailed account of the vegetation of 46 selected forest sites in Costa Rica, culminating in an ecological map, with an appendix presenting data from seven areas in Thailand. It is remarkable that these data were assembled in about two years even with hard work.

Holdridge's system is complicated, but this volume presents the first detailed discussion of the factors he considers important. The sites selected were studied by means of several types of aerial photographs, and supported by on-the-ground transects of the vegetation and a great deal of climatological data, as well as soil chemical and physical data. The presentation of facts is remarkably clear. For each area there are stereopair photographs, some in color; standard profiles of the vegetation, also interpreted as idealized profiles; soil profile diagrams; crown cover photographs for vertical visibility, and these compared with MEGA vegetation diagrams of the Dansereau school. The best explanation available of the MEGA vegetation symbolization forms Appendix III. The only discordant element in an extremely handsome layout is the computer print-out reproduction of the species encountered in the Costa Rica study areas. The presence or absence matrix of sample tree species by life zones, which accompanies the listing, is also followed by a listing of life zones indicating the dominant taxa within each zone.

The authors asked three questions: "Does the use of the Holdridge system contribute to the organization and understanding of field data and thus lead to increased predictability? Is it broadly applicable? Is it usable in practice?" They conclude the answer is "yes", but they have demonstrated the difficulty of gathering the data desired as well as the value of

their data for comparative purposes. They admit there remains a problem of developing a predictive system which will produce reliable information on under-canopy features from aerial observations. The man observing within the forest is still needed.

RICHARD A. HOWARD

The Complete Book of Flower Preservation. Geneal Condon. Englewood Cliffs, N.J.: Prentice-Hall, Inc. 1972. 210 pages, illustrated. $7.95.

The publisher's blurb describes Mrs. Condon's instructions as "simple". Lucid they are; simple they are not. The author narrates in assiduous detail her method of preserving fresh flowers, using Great Salt Lake sand. Other equipment is described and pictured. Sources for supplies are given when required. Absolutely fresh flowers are essential, negating the preservation of a bridal bouquet. A large, dry working area is necessary and the patience of Job would be helpful. Mrs. Condon suggests that a course in flower arranging is advisable. She covers every vegetative subject which can be preserved by her method and even recommends its use by students of botany. A teachers' manual, special treatment for special flowers, and answers to frequently asked questions offer still more information. The book is well-indexed.

If one feels intensely about flowers going through the cycle of life, assisting other forms of life in the process, seeding, and returning to the earth which nourished them, then this book is not for him. However, in 1972 it was in its fourth printing indicating a strong desire by many to preserve flowers.

MILDRED PELKUS

Linnaeus. Frontispiece from The Compleat Naturalist.

The Compleat Naturalist. Wilfrid Blunt. New York: Viking Press. 1971. 256 pages, illustrated, with an appendix by William T. Stearn. $14.95.

The fact that *The Compleat Naturalist* is a biography of Linnaeus should be enough to recommend the book; in addition it is so handsomely illustrated (32 color plates and numerous half-tones) that it is as much a joy to look at as it is to read.

William Stearn's contribution, "Linnaean Classification, Nomenclature, and Method", makes this definitive work more definitive, if that is possible, and provides a simple, clear explanation of Linnaeus' contributions to science.

The account of Linnaeus' life makes interesting reading for the most part. No man's life is continually compelling, and some parts of the book are less compelling than others; but that is no fault of the author. Often the serendipitous information is

as interesting as the main line of the biography. There is a fascinating picture of university life at Upsalla during the 18th century, for example, which makes you wonder how anyone survived an education. Blunt's account of life among the intelligensia of Europe, with their "curio cabinets" filled with treasures brought from around the world, also is interesting.

The biography of Linnaeus is a gold mine of botanical trivia, such as the story of *Linnaea borealis*, the only plant that bears Linnaeus' name. He described it as "lowly, insignificant, disregarded, flowering but for a brief space — from Linnaeus who resembles it."

DONALD M. VINING

Linnaeus' drawing of a cranefly. From The Compleat Naturalist.

Capability Brown & Humphrey Repton. Edward Hyams. New York: Charles Scribner's Sons. 1971. 248 pages, illustrated. $7.95.

The flowering of the 'Picturesque' or English landscape garden may be attributed primarily to 'Capability' Brown and Humphrey Repton. Mr. Hyams details the life of each artist tracing the evolution and refinement of his talent and the influence of the society in which he flourished.

Lancelot (Capability) Brown, following in the footsteps of William Kent, was the greatest exponent of this essentially new approach to planning and planting. The presentation of his life and work is used as a vehicle for the author's questionable theories concerning English gardening. Information must be sparse on the design and execution of Mr. Brown's landscapes, for the text becomes overinvolved with names and places; thus it fails to really capture either the character or the mind behind the genius who was to influence the course of landscaping and ultimately produce a master such as F. L. Olmstead.

Humphrey Repton, on the other hand, published several books on his work and, luckily for us, all of Mr. Repton's clients were presented with 'Red Books' which contained plans, paintings and sketches, and detailed explanations of all proposed work. Mr. Hyams takes advantage of this information and not only gives us a fairly comprehensive view of the Reptonian landscape, but introduces us to a fascinating and complex artist who characterizes the society of the late 1700's and early 1800's. Unfortunately the book does not provide us with adequate illustrations or plans, but there is a list of the surviving works of each man so one may view the artistry first hand.

JACK LINK

A Gardener's Guide to Plant Names. B. J. Healey. New York: Charles Scribner's Sons. 1972. 284 pages. $7.95.

This is an English book which has experienced a relatively painless transition to the United States. The bulk of the book is made up of an alphabetical listing of genera of plants in cultivation and their species, with translations of the Latin words. It will fulfill the author's purpose: "An excursion into the mysteries of botanical names; and, I hope, an answer to your friends who fix you with a glassy eye and ask, 'What's that in English?' "

Gordon P. DeWolf

A Revision of B. E. Dahlgren's Index of American Palms. Phanerogamarum Monographiae Tomus VI. Sidney F. Glassman. Lehre, Germany: J. Cramer Co. 1972. 294 pages. DM 120.

Dr. Dahlgren, in 1936, brought together in one index taxonomic and nomenclatural information on all species of New World palms. Since that time a Palm Society has been organized, with its publication *Principes*; several important books on palms have appeared, including an annotated checklist of cultivated palms, and many smaller monographic studies. Glassman's revision brings all sources together again by supplying an alphabetical list of names of New World palms. Accepted names and synonyms are indicated, along with basic bibliographic citations and designations of type specimens, and references to published treatments. A supporting bibliography cites papers into 1971. Appendices offer a geographical list of taxa by country, an enumeration of the genera, and the respective number of species.

This is an excellent reference volume for curators or collectors, and belongs in all botanical libraries.

Richard A. Howard

Boletus viscidus. *From* Exotic Mushrooms.

Exotic Mushrooms. Henri Romagnesi (ed.). New York: Sterling Publishing Co., Inc. 1971. 192 pages, 160 full page color illustrations. $12.95.

A coffee table book or micologists and others interested in mushrooms. The book consists mainly of 160 beautiful full-page color drawings of mushrooms. It might be useful for identification if you can get the mushrooms to the coffee table before they have discolored.

DONALD M. VINING

Your City Garden. Jack Kramer. New York: Charles Scribner's Sons. 1972. 120 pages, illustrated. $3.95 paperback.

The Country Garden. Josephine Nuese. New York: Charles Scribner's Sons. 1972. 256 pages, illustrated. $2.95.

The Southern Garden. Ben Arthur Davis. Philadelphia: J. B. Lippincott Co. 1971. 252 pages. $5.95.

What these three books have in common is the word "garden" at the end of a three-word title in which the second word is an adjective indicating the place where the garden involved may be found. Throughout this review I shall refer to the books by the distinguishing adjective.

I question the whole premise of *City*. It is a landscape architect's view of urban gardening — given world enough (and money enough) and time, you can manage to ignore the city entirely. The book is really about small gardens and the author assumes that city dwellers will be the most interested parties. Also, whichever city Mr. Kramer has in mind, it is not a city in the sense of urban Boston or New York where even dandelions have a hard time; he has a gentle city in mind, like Atlanta or Seattle, where gardening is not a struggle with a hostile land. Perhaps the title should have been *Small Gardens in Seattle.*

Country is a book to read straight through like a novel. It is Ms. Nuese's affair with gardening. There is a great deal of really good information tucked in among the honeyed phrases and, truthfully, a deal of good wit too.

Southern is the kind of book that sits on my shelves and induces guilt. It is organized on the "what-to-do-in-the-garden-on-May 6th" principle and as long as it is in the house, you will feel that there is something to do in the garden that you are not doing — which is always the case anyway, so you don't need a carping book. (*Country* is also arranged by months but you don't have to do anything about it.) That business aside, *Southern* is a pretty standard type garden book with lots of good lists of things to plant.

Donald M. Vining

Magnolia virginiana. *From* John Banister and His Natural History of Virginia 1678–1692.

John Banister and His Natural History of Virginia, 1678–1692. Joseph and Nesta Ewan. Urbana, Ill.: University of Illinois Press. 1970. 485 pages, illustrated. $15.00.

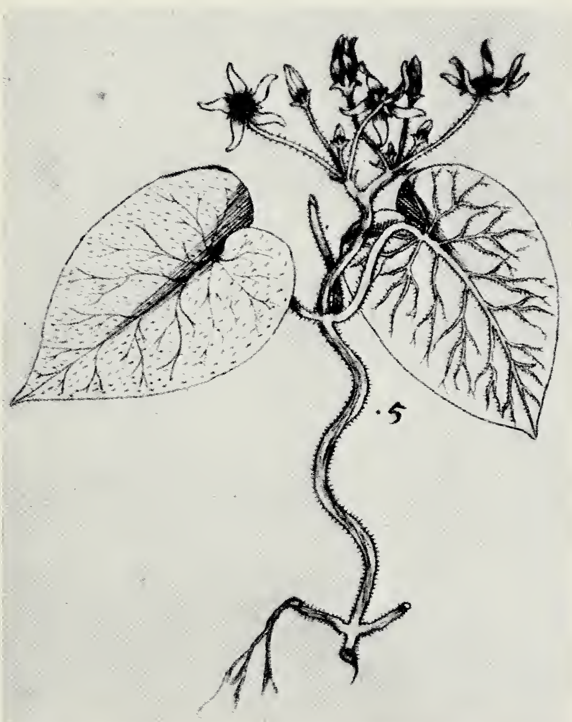
John Banister has been one of the legendary figures of American botany. He was an English clergyman, sent to Virginia to study and collect objects of natural history for Henry Crompton, Bishop of London. He arrived in America in 1678. He died after a shooting accident in May of 1692. In the interim he supplied his correspondents in England with natural history material, much of which was utilized by them without acknowledgement.

The Ewans have provided us with an eminently readable book. They tell us as much about Banister as they could find — and a very great deal about his contemporaries and correspon-

dents. Indeed this book is a veritable mine of information about 17th century English botanists. Annotated transcripts are provided of Banister's catalogs of plants, insects and arachnids, mollusca, fossils, and stones and "Mr. Banister's papers". Finally, 69 of his drawings are reproduced.

This book can be enthusiastically recommended to anyone interested in the history of biology in America.

GORDON P. DEWOLF



Gonolobus obliquus. *From* John Banister and His Natural History of Virginia 1678–1692.

Zander. Handwörterbuch der Pflanzennamen. Dr. h.c. Fritz Encke, Dr. Gunther Buchheim, and Dr. Siegmund Seybold (eds.) Stuttgart: Eugen Ulmer. 1972. 744 pages. DM. 42.

Although this little book is in German, its value is such that it should be brought to the attention of American readers. In the first place this book deals primarily with plants in cultivation. Its features include (1) a sketch of the systematic classification of the plant kingdom, (2) a list of the cultivated families of cultivated plants with a list of the genera included in each, (3) an alphabetical list of genera and species with directions for cultivation indicated by a series of conventional signs (a technique widely used in the last century), (4) a list of the abbreviated name of authors of plant names with their full names, dates, and brief biographical information, (5) a brief bibliography that indicates the outstanding current horticultural literature.

It is a book to stand on your desk beside the dictionary, for it will receive an equal amount of use.

Gordon P. DeWolf

Ferns and Palms for Interior Decoration. Jack Kramer. New York: Charles Scribner's Sons. 1972. 113 pages, illustrated. $6.95.

It is difficult to become enthusiastic about this book — but also difficult to condemn it. Its main strength lies in some very nice line drawings by Michael Valdez. There are many photographs which tend to be "arty" and not very diagnostic and the text is distinctly lightweight.

In fact, one could probably get all of the information here from a good one-volume horticultural encyclopedia.

This is a fairly good magazine article that has been blown up with photographs and wide margins to make a small book. In all fairness the price is not excessive.

Gordon P. DeWolf

Trifolium pratense. *Photo: P. Bruns*

ARNOLDIA *is a publication of the Arnold Arboretum of Harvard University, Jamaica Plain, Massachusetts, U.S.A.*

ARNOLDIA

The Arnold Arboretum Vol. 33, No. 6 Nov./Dec. 1973

Contents

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Front cover: Spring scene on Bussey Hill. Photo: P. Bruns

The Director's Report

THE ARNOLD ARBORETUM DURING THE FISCAL YEAR
ENDED JUNE 30, 1973

The calendar year 1972 was designated as the Centennial Year of the Arnold Arboretum, and the special program held the last week in May was described in the previous report of the Director. The second half of the year was no less a busy one for the staff, since the publicity continued to draw additional visitors to the grounds for scheduled meetings and casual visits. Features of the publicity proved to be our own film which was made available to colleges, schools, and private groups; an educational TV film by Thalassa Cruso, entitled "Changing Seasons", a tribute to the Arnold Arboretum, shown locally and on the NET; a feature section in the *Boston Globe*; and an article entitled "Harvard's Unique 'Bush Country' " which appeared in the *Ford Times*, a small magazine of very large distribution. One unusual side effect of the Centennial is worthy of note: Visiting botanists participating in the Centennial program were offered a tour which stopped at a bog in the town of Acton, Massachusetts. This focus of international attention on a small piece of vegetation led the Acton Conservation Commission to purchase the land and declare the Acton bog a nature preserve.

When the Olmsted Sesquicentennial was celebrated nationally in the month of October 1972, the Arnold Arboretum — being in part the handiwork of Frederick Law Olmsted — also was involved. Dr. and Mrs. Howard attended the opening of the national exhibit at the Mellon Gallery of Art in Washington. The Boston observance consisted of a small display and a reception in City Hall, with the announced theme a plan to revitalize Boston's parks. Later Brookline staged a more formal program, and offered the public visits to areas exhibiting Olmsted's influence; included were bus tours of the Arnold Arboretum guided by members of our staff.

Throughout the fiscal year the assistance of Volunteers, a group established for the Centennial program, was most effective. The training program which produced the first Volunteers

Jeep-drawn surrey transports springtime visitors around Arboretum grounds. Photo: P. Bruns

was repeated in 1972–73, and the graduates of the two programs are helping the staff in nearly every aspect of the work of the Arboretum. We are deeply indebted to these men and women for their contributions of time and talents.

An innovation tried experimentally for three weekends during the spring was the use of a rented, jeep-drawn, two-unit, open-seated vehicle for transporting visitors around the grounds. The "surrey" route had to be limited to areas of the Arboretum where the vehicle could be turned around, resulting in a convenient 50-minute ride through most of the conspicuous flowering tree and shrub collections. An amplifying system permitted the guides, who were either staff or volunteers, to comment to groups of 50 people. The fee charged produced a small profit over actual rental costs, and the surrey rides elicited a most favorable reaction.

Staff

Two resignations from the staff must be recorded for the past year. Dr. Lorin I. Nevling, Jr., resigned his position as Curator

of the Arnold Arboretum and Coordinator of Botanical Systematic Collections to accept a position as Chairman of the Department of Botany of the Field Museum of Natural History in Chicago. Ms. Ellen Bernstein resigned as Editorial Assistant for the *Journal of the Arnold Arboretum.* We value the services each has rendered to the Arnold Arboretum and seek their replacements.

We were saddened on January 2, 1973 by news of the death of the retired Librarian of the Arnold Arboretum, Mrs. Lazella Schwarten. Mrs. Schwarten served as librarian under three directors and during the most demanding period, when portions of the library were moved and both sections were reorganized. Her energy and effort were tremendous; in fact, perhaps she gave more of herself than she should have done. No librarian could have been more helpful to members of the staff, or more concerned for the properties under her direction.

Dr. Bernice Schubert and Dr. Richard Howard were named honorary vice-presidents of the First Latin-American and Fifth Mexican Botanical Congresses. A handsome certificate accompanied this honor and was accepted for both by Dr. Schubert, who attended the meetings. Dr. Howard also was elected president of the American Association of Botanical Gardens and Arboreta at the annual meeting held in Arcadia, California. The term of office is two years. Dr. Carroll Wood was elected vice-president of the Southern Appalachian Botanical Club.

Mr. Alfred Fordham, Propagator for the Arboretum, was honored by the International Lilac Society with an Award of Merit.

Community Service

The role of the Arnold Arboretum and its staff in community affairs has grown in scope and significance in recent years. Known as a "park" to many people, the grounds are open to driving weekdays and to walking from sunrise to sunset daily throughout the year. However, many of the visitors expect to have staff members present, facilities available to them, and someone to answer their questions in person or by telephone. From mid-April to mid-June in the last few years, the administration building has been staffed on weekends. Although the Volunteers have helped, the need still arises for staff members to be present, with the concomitant administrative problems of overtime, adjusted work weeks, or special employees. Friday night accumulations of litter require two men working all day on Saturday to pick up debris. Saturday night accumulations

of litter are not cleared up until Monday, with the result that there is often distasteful debris visible on a spring day of high visitor count. This weekend duty is expensive to the organization, and unwelcome in a society accustomed to Monday-through-Friday work schedules.

The professional competence of the staff and the resources of the organization also are subject to many requests for service. These include requests for plant identification and sources of plant material, information on culture or plant disease, aid in landscape design, conduct of classes or tours, and presentation of lectures and donations of plants for worthy environmental improvement programs. It is apparent now the requests exceed the abilities of a limited staff. Many requests, if fulfilled, exact the sacrifice of professional staff time more profitably devoted to research and publication. Some critical decisions must be made in the near future regarding this role of the Arnold Arboretum.

The Arnold Arboretum staff handles all questions regarding toxic plant materials, excluding only mushrooms, for the Boston Poison Center. These calls are most frequent in the spring and the fall, and are received at the administration building during working hours, but referred to the home telephones of several staff members after hours. During one month telephone calls on ingested plant materials averaged 30 a week; and over a year involved 74 different plants. About half of the evening calls are from doctors or emergency staff of hospitals. While most calls are from eastern Massachusetts, every New England state has been represented, as well as New York, Ohio, and Illinois in the last year. Realizing the need for public information on this subject of potentially poisonous plants, the Arboretum staff made poisonous plants the theme of its exhibit at the New England Spring Flower Show; plans an issue of *Arnoldia* on the subject; and has been engaged in the development of an educational film on the topic. Requests are on hand for the loan and purchase of this film which is still in production.

The Arboretum has a few houses on the grounds in Jamaica Plain, and on the Case Estates in Weston. Staff members who occupy these houses are in effect resident guards against fire and vandalism, and are sources of information for visitors to the collections. These duties often span 24 hours a day. No matter what community they live in, the staff members are called upon for professional services. Dr. Nevling served on the City of Boston Conservation Commission. Mr. Hebb is the representative of the Arnold Arboretum on the Board of Directors

Harry Hill and Arturs Norietis of grounds staff transfer conifers to the west nursery. Photo: P. Bruns

of the Jamaica Hills Association, and is a member of the Jamaica Plain Community Police Relations Committee. Miss Page is on the Cambridge Conservation Committee, and is chairman of the Cambridge Tree Committee. Dr. DeWolf is an advisor to the Weston Conservation Commission. Dr. Howard has served on special committees associated with school buildings in Weston, and has been on the Green Committee of Harvard College since its inception.

In 1972 Miss Nancy Page was appointed Coordinator for Community Activities, a position created to coordinate the many requests that come to the Arboretum from civic groups. Her activities have involved various groups in Jamaica Plain, Charlestown, Roslindale, Somerville, East Boston, Brighton, the South End, Back Bay, Dorchester, and downtown Boston. She has cooperated with the Boston Council, Boy Scouts of America, in their Explorer program, and has aided in the development of a vocational horticultural curriculum for the sixth grade of the Agassiz School in Jamaica Plain. Other staff members have served on committees or worked with such organizations as the Friends of the Public Garden, the Traphole Brook Protection Association, the Metropolitan District Commission, the Metropolitan Area Planning Council, the Boston Rehabilitation Association, the Massachusetts Bay Transportation Authority, the Boston Zoological Society, the New England Aquarium, the Model Cities Program, and the Suburban Experiment Station; as well as with three Boston TV stations, including WGBH, which was

given another donation of plants for the annual fund-raising auction.

Unlike other large arboreta or botanical gardens, the Arnold Arboretum has not had a specific program for the education of children. It has been felt that this role was filled adequately by the Children's Museum, the Massachusetts Horticultural Society, and the Massachusetts Audubon Society. Our efforts instead have been addressed to reaching school teachers, offering the invitation for classes under their direction to visit the Arboretum, and instructing them ahead of time on what to see and what to tell. Mrs. Harmony Spongberg, a Mercer Fellow, supervised a survey of horticultural and botanical activity in Boston area schools during the past year. A questionnaire sent to 451 teachers was answered by 105 from 78 public, private and parochial schools. Only one school offered courses in horticulture; none had a course in botany, although 19 offered some botany as part of general biology during a pathetically few hours a week. Six schools had greenhouses, four of these being private schools. Few indicated any encouragment of the students to bring plants to school, or to have gardens, or even plant trees on school property. About half of those replying indicated they took students on plant science field trips, and 17 indicated they had visited the Arboretum. In view of the interest expressed, two special tours of the Arboretum and the Case Estates were offered for teachers, and 35 attended. A special class, "Introduction to Plant Biology", was offered especially for instructors by Dr. DeWolf. Two workshops on house plants were conducted by Messrs. Hebb and Link at the Agassiz Community School in Jamaica Plain.

The Arnold Arboretum Achievement Award was given to Neil Gould of Jamaica Plain High School. This award of a choice of books and a specimen tree or shrub has now been presented six times. Schools are asked to submit a recommendation of an outstanding student in botany or horticulture. Recommendations have come largely from Jamaica Plain High School.

The article, "City Trees of Boston", developed by Dr. Weaver and published in *Arnoldia*, was reprinted and made available to local schools. With the aid of Miss Page this survey has been extended to the spontaneous plants and the common weeds. This study permits some professional observations on natural regeneration and the nature of invasion by plants, and provides some specimens for our herbaria. A check list will be submitted for publication in a professional journal, and a guide to the weeds is being prepared for publication in *Arnoldia*.

Oriental hybrid lily in experimental disease-resistance plot at Case Estates. Photo: P. Bruns

Messrs. DeWolf, Nevling, Weaver and Williams all have served as judges at science fairs in and around Boston, while Mr. Pride has been a judge of 4-H projects in the Dorchester-Roxbury Fair.

Staff cooperation with these various agencies has been both rewarding and frustrating. Considerable time was spent in the development of landscape plans for one rehabilitation program involving two park areas. The loss of federal funds completely terminated state and city interest in the project, in spite of the offer from the Arboretum of the major specimen trees, surplus to our needs, which would have enhanced the area at the nominal cost of moving the plants. By contrast, an appreciative letter was received from the Mayor of Somerville for the work of Nancy Page and others in the development of Riverside Park in that city.

The Metropolitan Area Planning Commission hopes, as part of the Olmsted celebration, to enhance the park system in Boston designed by Olmsted and referred to as the "emerald necklace". To learn what is present in these parks, what is worth saving, and what plants need attention, Dr. Weaver, with the help of the Misses Page and Hay, has mapped the Fens and Muddy River area between the Charles River and Longwood Avenue; the work continues. The Green Committee of Harvard, largely a group

of energetic students concerned with the plantings of the campus area, have requested information on the plants of Harvard and the associated natural history area. The Arboretum staff has helped in the development of a booklet to be available to students. One undergraduate undertook the task of mapping and naming, with the help of Dr. Weaver, all of the plants between the Charles River and the Biological Laboratories; the ultimate goal is to place labels on the most significant plants.

Community service by the staff in many ways has become a major role of the Arnold Arboretum.

Horticulture

Man and nature combined to make the care of the grounds more difficult than usual during the past year. Throughout the Centennial year the appearance of the grounds received more than the ordinary attention. We are obviously understaffed to have perfect maintenance of 265 acres in Jamaica Plain with twelve regular men, or of 110 acres at Weston with four men. The Arboretum does not need to be mowed to lawn level as long as the plants are cared for properly, labels are in place, and debris is kept to a minimum. Each of these objectives, however, has presented special problems. It is generally true that the quality of machinery has decreased; most aggravating is the unavailability of replacement parts for otherwise satisfactory equipment.

Vandalism remains a problem, along with the growing carelessness of some of the visitors. The administration building was broken into three times during the year, and typewriters, cameras, projectors, dictating machines, and miscellaneous materials were stolen. An alarm system now has been installed in the basement and first two floors of the building, so that any window or door broken for entry signals the Harvard University Police Department in Cambridge. They in turn call a member of the staff and the Boston Police, who must investigate. Within the building, fire doors or other doors between rooms and sections are locked, often with chains or padlocks. Not only is the installation expensive, but the increased inconvenience nearly eliminates the possibility of voluntary staff work evenings or weekends.

It has been a normal procedure for the records staff to check about one-fifth of the living collection annually. Since all of the grounds are mapped, new additions to the collection must be added to the maps. The inspection reveals the conditions of the existing plants, the presence of weed trees or the growth

Accumulation of weekend litter mars conifer collection. Photo: A. Fordham

of understock, and the presence of the display labels. During the winter nearly one-half of the labels in one large part of the collection was stolen, and a large number was switched. An examination of other parts of the collection indicates a similar situation. Our records are such that the important data is not lost, and labels can be replaced, but our ability to present a labeled collection is sorely tested.

Additional trash barrels have been placed on the grounds, but even these must be chained to posts or trees. The presence of such receptacles in large numbers is not attractive, and they are not used by many visitors. The weekend of April 14–16, Patriot's Day weekend, was unusually pleasant and warm; as a result, young people congregated and the after-dark assembly is best described as a mob. Tuesday, the 17th, the conifer collection and the hillside near the administration building resembled a windblown dump; the area was literally covered with paper, bottles and cans. It required the work of the full ground crew for the rest of the week to pick up the debris. Unfavorable publicity appeared in the Boston papers, and a petition was received from the neighbors to "Save the Arnold Arboretum." A meeting was arranged with the Park Commissioner, the Boston Police, and representatives of Harvard and the Arboretum. As a result, we have received significantly more police attention.

It should be noted that Captain Quinlan and Deputy Superintendant Blair have been most cooperative. It also has been possible, with the cooperation of the Traffic and Parking Commission, to declare three bays in entrance areas as tow zones after dark. The signs indicating this are effective until they also are stolen. Further consideration must be given to more adequate fencing, restricted hours of admission, and perhaps an admission charge. The City does not contribute to the cost of maintaining a clean arboretum, and the Arnold Arboretum budget cannot supply additional guards or labor without eliminating some other program.

Nature, too, had a role in the exceptionally cool and wet spring of 1973. There may be lasting effects from major infestations of canker worm on plants of *Carya*, *Juglans*, *Quercus*, *Acer* and *Tilia*; of anthracnose on *Carya*, *Quercus*, and *Platanus*; and of blight on species of *Juniper*. Although sprays will control such outbreaks, they must be used judiciously; unfortunately the recurrent rain washed away the material before it was fully effective.

Following the Centennial, the dwarf conifer collection on terraces in the greenhouse area was renovated. Thirty overgrown

specimens were removed from the planting and established elsewhere on the grounds.

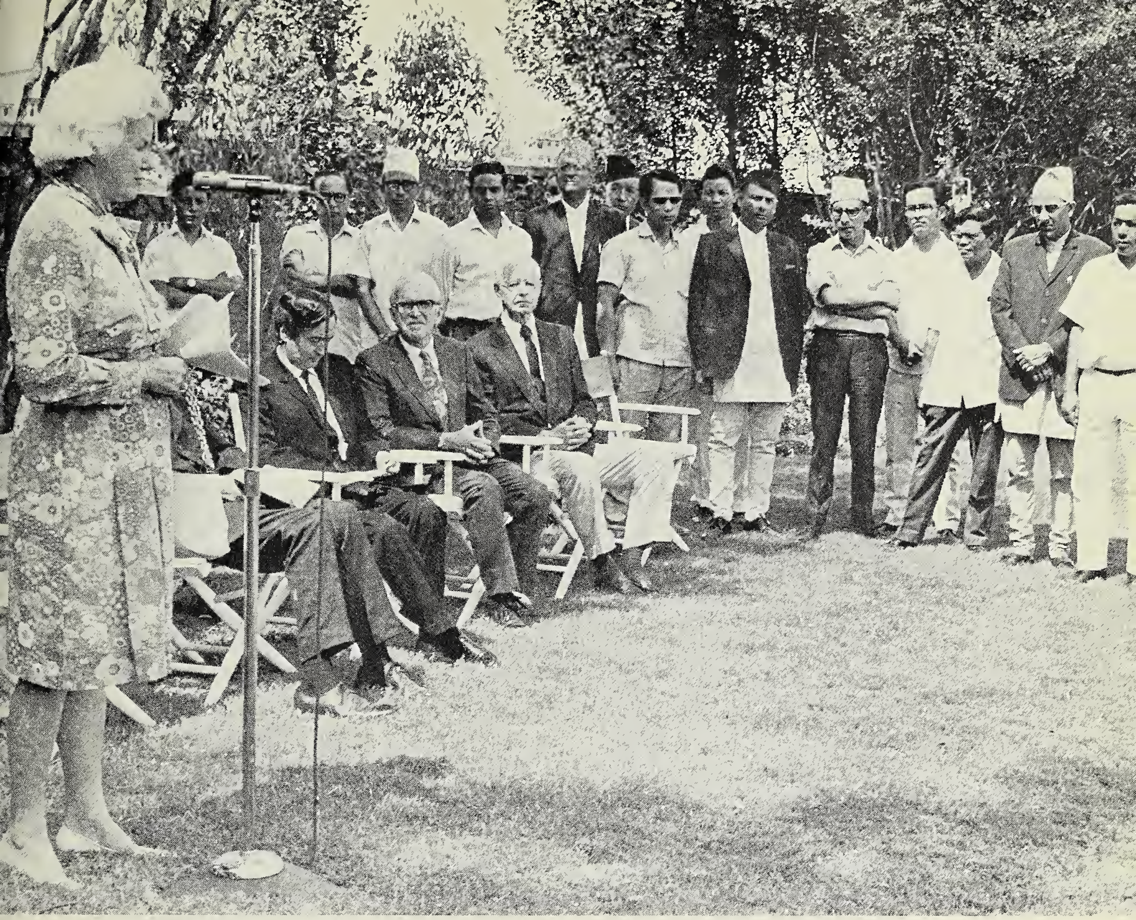
A total of 717 plants was added to the collections by transfer from the nursery area to permanent planting. A total of 211 new taxa was included, but this number is offset by the loss of 67 taxa during the year through lack of hardiness or by theft.

The Propagation Department received, from expeditions or from exchange with other botanical gardens, 243 shipments of plant materials representing 1,360 taxa from 26 countries. Of these, 119 shipments, or 754 taxa, were plants or vegetative propagating material, while 124 shipments were seeds of 576 taxa. Many of these are potential additions to our collections, while others are plants for experimental work or for special study by members of the staff. In response to requests, the staff sent 124 shipments of plants or vegetative propagations of 401 taxa, and 29 shipments of seeds of 69 taxa to eight countries. Plants of *Malus* 'Donald Wyman' and *Magnolia* 'Centennial' were offered in quantity to cooperating nurserymen. Both plants are newly-named selections of the Arboretum staff. During the Centennial plants were offered to other gardens, colleges, and communities, and requests for such plants that could not be filled at the time are being completed. One of the most unusual requests came from Nepal for a specimen of sugar maple. Such a plant was sent by diplomatic courier.

The records of plants within the collections of the Arnold Arboretum are in the data bank of the Plant Records Center, American Horticultural Society. Any initial computer program reveals duplication of numbers, factual errors, and errors in naming and spelling. Each error must be checked and corrected. We also are attempting to incorporate into the computer records the original source of all plants now living. An original introduction by Wilson may have died of old age, but seedlings or propagation of the original plant may remain; current records show only that the present plant is a propagation of an earlier number. The many bits of detective work involved, historical in nature, will increase the value of the record when completed. Messrs. Hebb and Link, with the welcome help of some volunteers, are making progress on these corrections and additions.

A new printing machine has been acquired to permit the staff to make its own blueprints and permanent sepia transparencies. This machine will facilitate our record keeping and allow us to make copies of our maps for the use of visitors seeking specific collections for study.

Domingo Rivera, Peter Ward, and Timothy O'Leary, grounds staff members, move tree from east nursery. Photo: P. Bruns



Above: Recognition of Service ceremony in Kathmandu, Nepal, honoring the late Ambassador Henry E. Stebbins, a Friend of the Arnold Arboretum. The present ambassador, Carol S. Laise, is seen addressing some of former Ambassador Stebbins' friends.

Left: Ambassador Laise and her husband, Ambassador Ellsworth Bunker, immediate predecessor to Ambassador Stebbins, plant small American sugar maple supplied by the Arnold Arboretum for memorial observance in Nepal, May 30, 1973.

The registration of cultivars of woody ornamental plants is a service of the Arboretum staff to American and international horticulture. The Arnold Arboretum is the international registration authority for a large number of genera; its records offer service for other groups of plants as well. During the past year 50 registrations were received for new cultivars. Descriptive material on these has been published in *Arnoldia*, but may in the future be placed in the *Bulletin of the American Association of Botanical Gardens and Arboreta.* The number of registrations is higher than in the past, due to the efforts of the staff to locate data on these plants in reference to our collections and to our work on Rehder's *Manual.* Registrations are rarely volunteered; the majority are solicited. We have been able to acquire authentic material for our living collections through our efforts, and therefore can prepare herbarium vouchers as well.

The annual meeting of the International Lilac Society was held at the Arboretum in Jamaica Plain and at Weston on May 25–26, 1973. The group honored the Arboretum with a special plaque.

Case Estates

The Case Estates' 110 acres are located in the town of Weston, 13 miles from the plantings in Jamaica Plain. The land is used primarily as a nursery for young plants propagated in the greenhouses at Jamaica Plain, and for the permanent holding of taxa for which there is neither room nor desire in the Jamaica Plain plantings. Some special display collections are maintained at the Case Estates, and one building is available for lectures, classes and meetings. The area is attractive and parking has not become a problem, so the number of visitors to the Case Estates is increasing. A publicized "open house" on a Sunday in May drew over 1,000 visitors as represented by 600 cars counted during the day.

Classes and lectures were held this year in the fall and the spring, and were well attended by persons who will not venture into the city. Special groups included members of The Massachusetts Federation of Garden Clubs and the Garden Club of America districts, as well as meetings of the International Lilac Society, the American Begonia Society, and societies concerned with rock gardens, rhododendrons, hemerocallis and iris.

The Case Estates' grounds are maintained by a staff of four men, supplemented during the summer by student help. We were fortunate to have more highly qualified student help than in previous years, and some much-needed work was accom-

plished. The permanent and growing nurseries were pruned; the narcissus bulbs were lifted from overgrown display beds, the soil fumigated, and the bulbs replanted. Many trees were removed where collections of *Ilex* and *Rhododendron* had become overshaded.

Surplus plants from the nursery are offered first to Harvard University, and many were accepted for use in Cambridge and at the Business School. Several colleges in New England also accepted larger plants of botanical or horticultural interest. Smaller surplus plants were offered to the Friends of the Arnold Arboretum on an annual "give-away" Saturday, and a few more than two hundred people arrived for the first-come-first-choice distribution.

Discussions continue with the Sidewalk Committee of the Town of Weston regarding the development of a bike path and sidewalk along the hazardous Wellesley Street frontage. Involved are some unique historic stone walls, partly dry walls, with a long line of large single stones. These will be expensive and difficult to move if the walk cannot be placed behind them. One row of *Malus* 'Henrietta Crosby' planted about 25 years ago has matured to give a spectacular display every spring. These trees are too large to move, and their preservation has become a public issue. The alternative is to place the sidewalk well into the Arboretum property, sacrificing other collections, giving up valuable nursery space, and destroying the front yards of two Arboretum houses.

The Herbarium

The Director's Report last year noted the award of a grant, renewable annually for five years, from the National Science Foundation to the Harvard Botanical Institutions for support of curatorial activities in the herbarium and the library. The grant (GB 33856X1) is shared by the Arnold Arboretum, the Botanical Museum, the Farlow Herbarium and Library, and the Gray Herbarium. During the first year of operation, the new funds permitted additional mounting of herbarium specimens to make available the backlog of unmounted and often unstudied collections. Additional personnel were hired for the insertion of the increased number of specimens mounted, and one person was assigned the task of checking our holdings against recently published monographs. Some aid was allotted to the purchase of supplies and materials; in a future year, when space is acquired for them, additional herbarium cases will be purchased. Allocations to the library will be discussed later.

During the year, 29,319 specimens were mounted and inserted, bringing the total for the herbarium of the Arnold Arboretum to 1,000,559 mounted specimens, of which 151,609 are cultivated plants and are housed in Jamaica Plain. The Arboretum received 6,182 specimens in exchange, and 5,953 under a subsidy program. The purchase of the 5,000-sheet herbarium of the Hesse Baumschule in Germany is especially valuable, since this herbarium was built up as a study collection of plants cultivated in Germany. The collection is on oversized sheets, with data handwritten on them. Several of the Volunteers have undertaken the task of remounting the specimens and preparing typed, long-lasting labels. The Hesse Herbarium will be added to the collections of cultivated plants in Jamaica Plain, and can be accommodated in available cases and space. The housing of specimens in Cambridge, however, is increasingly difficult. At present, over 2,053 cardboard boxes, representing approximately 114 steel cases, are used on top of existing cases. These boxes of specimens can be reached only by ladders, and so are difficult to use, and constitute a barrier interfering with the circulation of air in the building. A report on the space problem, with recommendations for readjustments and new space as an addition to the building, has been submitted to the administration of Harvard University. For some immediate relief of the crowded conditions for the housing of staff and collections, the Botanical Museum made some space available to the Museum of Comparative Zoology in exchange for space in the Agassiz Museum contiguous to the third floor of the Harvard University Herbaria building. Renovations should be completed in the next year and offer some relief — primarily as office-laboratory space.

Requests for the loan of herbarium specimens, noted as greatly increased last year, continued at the increased rate. Such requests are filled with specimens from both the Arnold Arboretum and Gray Herbarium collections, and with cultivated specimens from Jamaica Plain when appropriate. From the several collections, 23,237 specimens were sent as 190 loans to 59 institutions in the United States, and to 33 institutions in 20 foreign countries. The outgoing loans averaged 122 specimens. For staff and student research, 7,007 species were borrowed as 96 loans from 36 institutions, and averaged 73 specimens. Student use accounted for 36% of the loans and 45% of the specimens.

The additional help made possible by the grant also was applied to the wood and fruit collections. These are being upgraded by the removal of undocumented materials, while the collections

Friends of the Arnold Arboretum study offerings at annual plant give-away. Photo: G. Wadleigh

remaining are now placed in sealable plastic bags to reduce the danger of spillage and infestation, and to maintain cleanliness.

The history of the wood collections has been compiled by Dr. Ralph Wetmore. While the Arboretum many years ago assumed responsibility for the collection through the work of Professor I.W. Bailey, it appears, on a legal basis, that the material was accumulated and maintained in the early years with funds from the Department of Biology and the Bussey Institution; and only later, the Arnold Arboretum. Resolution of the proper responsibility for the wood specimens has not been made. The space currently occupied by the collection in the Harvard University Herbaria building is more urgently needed, and the collection will be moved to new basement quarters in the Botanical Museum. The NSF grant will permit the acquisition of new slide holders to replace the old-style wooden boxes now in use, resulting in considerable compaction.

The normal research activities of the staff were disrupted by the special demands of the Centennial year program. This is clearly reflected in the reduced bibliography of published papers. Schedules are returning to normal, and the following types of research activities are in progress: Floristic studies are the work of Dr. Howard on the Lesser Antilles; Dr. Hu on the Flora of Hong Kong and the New Territories; Dr. Nevling on the Flora of Veracruz, Mexico; and Dr. Wood and associates on a Generic Flora of the Southeastern United States. Monographs and other systematic studies were undertaken by Dr. Howard, who completed a treatment of the Piperaceae in the Lesser Antilles, and a study of Jacquin's *Enumeratio*; Dr. Robertson, who is completing a treatment of the Rosaceae for the Generic Flora project; and Dr. Schubert, who continues her studies of *Dioscorea* and *Desmodium*. Dr. Spongberg is working toward a revision of Rehder's *Manual*, with current emphasis on the Theaceae. Dr. Weaver is studying tropical Gentianaceae. Drs. Hartley and Perry have completed an enumeration and key to the species of *Syzygium* in Papua, New Guinea. The staff is supervising the studies of two students investigating *Lonchocarpus* and *Portlandia*.

Library

The curatorial grant from the National Science Foundation has permitted improvement in the facilities and care of the library collections. For Jamaica Plain used library stacks were purchased and painted by the grounds staff during the winter. The addition of nearly 3,000 running feet of shelving has al-

leviated crowded conditions and will permit expansion. In Cambridge the old steel card cabinets holding the general catalogue have been replaced with modern wood and plastic files, greatly increasing the convenience of use through smaller drawers. File cabinets were added to the Torrey Card Index. The reading room has been reorganized in a more pleasing and practical manner. A new compact table-top microfiche reader was obtained. The grant has also permitted an increase in the retrospective binding of old publications and periodicals.

The holdings of the library of the Arnold Arboretum were increased by 1,296 items to a total of 81,909 catalogued volumes. Currently 637 periodicals are received by the Gray Herbarium and Arnold Arboretum, forming a truly excellent library for botanical and horticultural research. Additional microfiches of herbaria and books are purchased jointly, with the current holding comprising 9,222 microfiche cards.

Books charged within the library totaled 4,579 during the year, with 1,338 volumes charged outside of the library. A survey of the use of the library in Cambridge over a period of several months revealed a ratio of 8–3–1 in use by staff, students, and visitors.

Stephanne Sutton, Honorary Research Fellow, has completed a biography of Joseph Rock, plant collector for the Arnold Arboretum for many years. A publisher is being sought for this manuscript.

Education

The educational program of the Arnold Arboretum involves formal teaching at Harvard; participation in the guidance of graduate and undergraduate students; noncredit informal courses at the Arboretum in Jamaica Plain and Weston which are attended by adults and students alike; many public lectures, radio and TV appearances; a publication program which includes our regular journals as well as newspaper and magazine articles not cited in staff bibliography; and many displays and exhibits.

During the spring semester, Dr. Carroll Wood offered Biology 103, an elementary course in the taxonomy of vascular plants. Twenty-two regular students plus auditors made this the largest class in this subject in nearly two decades. He offered research courses Biology 96 and 91r to special students, and cooperated with Professor Tomlinson in teaching a summer school course in tropical botany which met for three weeks in Miami, and a following week in Cambridge. Dr. Howard pre-

Arboretum staff members, Jack Link, Robert Hebb, and Gordon DeWolf, instruct class in practical horticulture. Photo: P. Bruns

sented Biology 209, an advanced class in phylogeny and evolution of flowering plant families. Dr. Schubert and Dr. Wood were undergraduate student advisors for the Biology Department, and combined to conduct the botanical seminars held in Cambridge at the Herbaria building.

Among the noncredit courses offered in Jamaica Plain and Weston, Dr. DeWolf offered plant biology for instructors, and two field courses in ornamental plants; Dr. Weaver taught courses in natural history and in plant identification; Mr. Hebb presented a course in basic gardening; and Drs. Wood and Howard repeated a course in economic botany called "Botany in Boston's Restaurants".

Mrs. Derderian conducted workshops on bonsai; and numerous demonstrations of plant propagation were offered by Mr. Fordham to visiting classes and groups at the greenhouses. Among the special programs open to the public were open houses in Jamaica Plain and Weston with staff members on the grounds to answer questions; a special all-day symposium on "Botanical and Horticultural Resources of Massachusetts", with twelve organizations participating; instructors' tours of the collections in Jamaica Plain and Weston, particularly for elementary and high school teachers; and a vegetable gardening class limited to teachers and leaders of local community garden projects.

For the N. E. Spring Flower Show of the Massachusetts Horticultural Society, the Arnold Arboretum, in cooperation with

Above: Arboretum's poisonous plants display at N. E. Spring Flower Show draws inquisitive viewers. Photo: P. Bruns

Below: Mrs. Sheila Geary, Arboretum assistant librarian, explains procedures to class of Volunteers. Photo: P. Bruns

the Botany Department of Wellesley College, offered an exhibit of potentially toxic or dangerous plants. Miss Bruns prepared large, colorful backdrops to illustrate many of the plants, and these have been used repeatedly in other exhibits. Material had to be forced for this display, and movies of many of the plants were made to be used in an educational film under preparation on the subject of poisonous plants.

An exhibit of photographs of the work and collections of E. H. Wilson, prepared for the Centennial program, was requested for display elsewhere in smaller units, but the full exhibit was sent to Callaway Gardens, Pine Mountain, Georgia, for display in their educational rotunda. Miss Page organized two exhibits for Earth Day activities in Boston and Brookline — a pruning display and a composting display, respectively; also, an exhibit of seeds and fruits of woody plants for the Boston Cityfair. During the Boston Fenway Garden Day, she assisted in an exhibit of propagation methods for cuttings of woody plants. Mr. Hebb supervised a display of woody ornamental plants for a Christmas Show sponsored by the Massachusetts Horticultural Society.

Mrs. Geary prepared exhibits on the work of the Arnold Arboretum for display in the Lexington, Wellesley, and Milton public libraries; and an exhibit on roses, using books, specimens and embedded flowers of roses, for the Rose Society Show held at the Natick Mall. An exhibition of the painting and drawings of the late Joseph B. Martinson was held in the administration building, with an introductory lecture by Dr. Howard on the staff projects in Puerto Rico. An exhibit of color photographs by John F. Carter also attracted attention in the administration building during the spring.

The Arboretum Centennial film was shown many times by staff and Volunteers to groups requesting it in the Boston area. During the spring it was shown on a regular schedule preceding the surrey rides around the grounds and it has been borrowed by many colleges, universities, botanical and horticultural clubs. Its most distant showing was in Colombia, South America, where the director of the botanical garden at Medellin prepared a tape in Spanish to accompany it when it was shown to local audiences. The film was entered in competition at the film festival of the American Horticultural Society at its annual conference, and was given the Society's Award of Merit.

Requests for staff members as speakers at various horticultural meetings, and at colleges and universities, exceed our ability to accept every invitation. Nevertheless, seven staff

Davidia involucrata. *Photo: P. Bruns*

members spoke in 17 states and presented three lectures in Canada during the year. Various staff members attended the meetings of the American Institute of Biological Sciences in Minnesota and Massachusetts; the American Horticultural Society in Seattle, Washington; the American Association of Botanical Gardens and Arboreta — annual meetings in Seattle, Washington, and Arcadia, California, and a regional meeting at the Brooklyn Botanic Garden; the United States Department of Agriculture open house in Beltsville, Maryland; a Systematic Symposium at the Missouri Botanic Garden; the International Propagators' meting in Hartford, Connecticut; the American Rhododendron Society meeting in Pittsburgh, Pennsylvania; and the Linnaean Symposium at the Hunt Institute for Botanical Documentation in Pittsburgh. The First Latin American and Fifth Mexican Botanical Congresses were held simultaneously in Mexico City, and were attended by Dr. Schubert and Dr. Nevling. Dr. Nevling represented the Arboretum in discussions of national systematic resources in Washington, D.C., and Claremont, California. He also attended a special Tropical Ecology workshop in Turriabla, Costa Rica.

Travel and Exploration

The travels of the Arboretum staff may be for field work, meetings, or lectures, but each trip is an opportunity to make botanical observations, collect special materials for staff research, or obtain photographs useful in teaching. Dr. Hu spent eight months of the past year in Hong Kong. She offered courses in taxonomy and local flora at Chung Chi College, and involved the students in obtaining material for her work toward a flora of the area. Dr. Wood took two classes to Florida and preserved a considerable number of plant parts from which an artist can prepare illustrations supporting his work on the Generic Flora of the Southeastern United States.

Dr. Schubert attended a meeting in Mexico City, and visited adjacent areas as well as the state of Veracruz to find material of *Dioscorea*. Dr. Nevling continued his work on a flora of Veracruz which is supported by a grant from the National Science Foundation.

Dr. Gillis, a Research Fellow, visited several islands in the Bahamas, as well as the Turks and Caicos, seeking new collections and illustrative material for his research. A grant from the Atkins Fund was awarded to Dr. Weaver, enabling him to visit Venezuela and Colombia to collect tropical members of the gentian family. Mr. Pride had a vacation safari to Kenya

and Tanzania, acquiring useful pictures for his lecture programs, and some plant material.

Dr. and Mrs. Spongberg traveled to South Carolina in the spring, and worked their way north, visiting botanical gardens, and making collections related to his work on a revision of Rehder's *Manual.*

To increase the collection of lilac cultivars in the Arnold Arboretum, Mr. Hebb visited the Royal Botanical Gardens in Hamilton, Ontario, Canada, where the newer European varieties are grown which we have been unable to obtain directly from Europe.

Research Fellows

A small portion of the income from the Mercer Fund of the Arnold Arboretum has been designated each year to permit the support of qualified persons to visit the Arnold Arboretum for study and experience. A graduate student from Mexico, Mario Sousa-Sanchez, has been supported in his studies of the genus *Lonchocarpus*, using both the herbarium and the greenhouses. Harmony Clement Spongberg received a renewal fellowship to investigate the nature of botanical and horticultural teaching in the Boston area and determine the role the Arnold Arboretum should or could play. James Wolpert, a graduate of Purdue University, received a fellowship to learn more about arboretum activities and management problems. Martha Dahlen, an undergraduate at Purdue, received summer assistance to learn herbarium techniques.

A gift to the Arnold Arboretum from an anonymous donor carried the wish that the fund be used for the study of the flora of the Bahama Islands. Dr. William Gillis was awarded a research fellowship to enable him to pursue his studies in that area, using the extensive collections in the Arboretum herbarium.

The number of applications far exceeds our ability to support or to house the many candidates with excellent recommendations. The fundamental idea behind the fellowship is to permit the recipients to use our collections of books, specimens, and living plants to increase their knowledge of an arboretum and its activities through close association with staff members.

Volunteers

During 1972, the Centennial Year, the Arboretum staff offered an instructional program of 13 weeks' duration to prepare a group of volunteer men and women to help the Arbo-

Mrs. Lowell Trowbridge, member of Volunteers, at work in Dana Greenhouses. Photo: P. Bruns

retum staff with the Centennial program. Mrs. Paul Wechsler gave a great deal of time and thought to the coordination of the training program, and then to the utilization of these people and their varied talents during the year. A second program was conducted in the fall for a new group. The staff is extremely grateful for the dedicated, efficient, and most helpful role the Volunteers have played in many aspects of the activities of the Arboretum. They have helped staff the building, answer the telephone, lead guided tours, work in the greenhouse, type, collect and dry herbarium specimens. They have assisted in the library, and have helped renovate the special collections on the Case Estates, take inventories, organize photographic files, prepare labels, prepare displays, answer questions at the flower shows, check computer printouts, search records of books for information, and dissect and draw for staff research projects; and have been useful in many unexpected ways. Several Volunteers under staff guidance collected on a regular basis from the living collections a total of 522 numbers and 1,567 specimens which can be used for exchange. One talent worthy of special mention is that of Mrs. Frank Magullion, who has perfected a technique of drying flowers and embedding them in blocks of clear plastic. The results

are beautiful and useful. The blocks are on display at the administration building, and have been used in classes taught by the staff. To all of the Volunteers the staff, collectively, expresses its appreciation for the help it has received.

Gifts and Grants

The income from the endowment of the Arnold Arboretum and from the special Mercer Trust covers only 75% of the expenditures of the organization. Gifts and grants make up the difference, and offer the only means of meeting the inflation of costs in the present economy without reducing the activities and number of the staff. We are most grateful for the repeated annual gifts from the Friends of the Arnold Arboretum. Facing rising costs in all aspects of our work, we will request an increase in the basic contribution of a Friend from ten to fifteen dollars in 1974. A Friend receives six copies of *Arnoldia*, miscellaneous mailings offering classes, lectures, tours and demonstrations, and an annual offering of surplus plants from our nurseries. The cost of these benefits leaves only four dollars, the equivalent of one hour of average labor on the grounds, from a ten-dollar gift. We believe the Friends mean to support the work of the Arnold Arboretum by their membership and gifts. The increase proposed will assist a very great deal.

Memorial gifts have been offered to the Arboretum on many occasions, and are gratefully received. Such gifts are acknowledged and recorded in our files according to the donor's wish. A gift fund for special purposes may be established; a plant on the grounds may be marked with an appropriate small metal embossed label; or a bookplate, indicating the donor and the one memorialized, may be placed in a library volume. Memorial gifts were received in the names of Peter K. Boshco, Joseph Alexander Boyer, Dorothy Paine Brayton, Helen Barnet Gring, Mrs. Lillian Cassat Smith, and Mrs. Florence Dorward Wyman.

Grants in support of travel were received from the Atkins Fund and an anonymous donor. National Science Foundation grants support curatorial activities as well as projects on the flora of Southeastern United States and Veracruz, Mexico. An anonymous gift permits special work toward a revision of Rehder's *Manual of Cultivated Trees and Shrubs*. A grant from the Tozier Fund (Harvard University) was made to Dr. Howard to develop illustrative teaching aids for an advanced taxonomy class. A gift from the Rare Plant Group of the Garden

Cornus florida. *Photo: P. Bruns*

Club of America was presented in recognition of the willingness of the Arboretum staff to share rare plant materials.

Generous gifts of plant materials were received from the Mitch Nurseries, the Monrovia Nurseries, and the Simpson Orchard Company. These often were Arboretum plant orders filled without charge. Many other companies offered generous discounts which also were appreciated.

Individuals have donated books to the Arboretum during the year. These often have been additions to our collections, duplicates needed to reduce the wear of present holdings, or surplus to our needs which can be used in exchange. Gifts of library volumes, gratefully acknowledged, were from Mrs. Konrad Braun, G. Buchheim, Jay Fritz, Augustus Kelley, Merle Myerson, James H. Wilder, and Mrs. John Wind. Many publishing companies have sent books for the library with the request that they be reviewed. Such reviews are published in *Arnoldia* when the staff feels the volume is of interest to the Friends and subscribers to *Arnoldia*. We are grateful for these further marks of generosity to the Arnold Arboretum.

Publications

The regular four issues of the *Journal of the Arnold Arboretum* and six issues of *Arnoldia* were published during the fiscal year. The *Journal of the Arnold Arboretum*, edited by Dr. Bernice Schubert, comprised 638 pages with 27 articles by 33 authors. A new decorative cover, of *Ginkgo biloba*, was prepared for Volume 54 by Karen S. Velmure. Ms. Ellen Bernstein, Editorial Assistant, compiled and prepared an index to authors and titles of articles published in the first fifty volumes. Dr. Schubert prepared a short history of the *Journal of the Arnold Arboretum* as an introduction. Publication is scheduled for the summer of 1973.

Arnoldia was edited by Mrs. Jeanne Wadleigh, with artistic and layout help from Miss Pamela Bruns. The six issues comprised 371 pages, including 243 pages devoted to the botanical and horticultural Centennial symposium lectures. These lectures also were bound separately for future distribution.

RICHARD A. HOWARD

Staff of the Arnold Arboretum

1972–1973

Richard Alden Howard, Ph.D., *Arnold Professor of Botany, Professor of Dendrology and Director*

Karl Sax, S.D., *Professor of Botany, Emeritus* ‡
Donald Wyman, Ph.D., *Horticulturist, Emeritus*

Ellen Bernstein, M.A., *Editorial Assistant* *
Pamela Anne Bruns, B.A., *Artist and Art Director of Arnoldia*
Michael Anthony Canoso, M.S., *Manager of the Systematic Collections* †
Constance Elizabeth Derderian, *Honorary Curator of the Bonsai Collection*
Gordon Parker DeWolf, Jr., Ph.D., *Horticulturist*
Alfred James Fordham, *Propagator*
Sheila Geary, B.F.A., *Assistant Librarian*
William Ed Grime, B.A., *Curatorial Assistant* †
Patricia Dick Hall, M.S., *Librarian* †
Ida Hay, B.A., *Herbarium Assistant*
Robert Stephen Hebb, B.S., *Assistant Horticulturist*
Shiu-Ying Hu, Ph.D., *Botanist*
Thomas Matthew Kinahan, *Superintendent, Case Estates*
Jack Link, B.S., *Curatorial Assistant*
Lorin Ives Nevling, Jr., Ph.D., *Curator and Coordinator of Systematic Botanical Collections* **
Nancy Markham Page, B.A., *Coordinator for Community Activities*
George Howard Pride, M.A., *Associate Horticulturist*
Kenneth R. Robertson, Ph.D., *Assistant Curator*
Bernice Giduz Schubert, Ph.D., *Curator and Editor of the Journal of the Arnold Arboretum*
Stephen Alan Spongberg, Ph.D., *Assistant Curator*
Stephanne Barry Sutton, A.B., *Honorary Research Fellow*
Karen S. Velmure, B.A., *Botanical Illustrator*
Jeanne S. Wadleigh, B.S., *Editor of Arnoldia*
Richard E. Weaver, Jr., Ph.D., *Assistant Curator*
Robert Gerow Williams, B.S., *Superintendent*
Carroll Emory Wood, Jr., Ph.D., *Curator and Professor of Biology*

* Resigned July 15, 1973
** Resigned June 30, 1973
† Appointed jointly with the Gray Herbarium
‡ Deceased October 8, 1973

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Notes from the Arnold Arboretum

The weather during 1972 was characterized by overcast skies and abnormal precipitation. Observations at the National Weather Service, Logan International Airport, show total precipitation of 53.11 inches — 10.21 inches above normal. Average precipitation for Boston is 42.77 inches. Precipitation at the Arboretum during 1972 was 60.85; thereby exceeding the Boston average by 18.08 inches. It is not unusual for weather data at the Arnold Arboretum to differ widely from those at the Boston Weather Station, particularly during periods of summer storms.

The following table, however, shows a year when precipitation at the Arboretum exceeded that at the Logan Airport during each month; these two weather stations are seven miles apart.

Comparative Monthly Precipitation Totals

1972

	Weather Station Logan Airport	Arnold Arboretum Weather Station
January	2.05	2.35
February	5.29	5.82
March	5.37	6.22
April	3.34	3.62
May	5.26	5.28
June	6.76	7.17
July	2.18	3.87
August	0.83	1.16
September	5.94	7.12
October	2.98	3.33
November	7.72	7.80
December	6.02	7.11
Total Inches:	53.11	60.85

Boston's record for the least amount of sunshine in any year toppled in 1972. A total of 2250 hours (about 50% of that possible) was observed. This was the least sunshine recorded in any year since records were first started in 1893. December

set a new low record for sunshine with a total of 59.9 hours, or only 21% of the potential.

ARNOLD ARBORETUM WEATHER STATION DATA

Average temperature for 1972: 49.1°
Precipitation for 1972: 60–85 inches
Snowfall during winter 1971–1972: 54.5 inches
Warmest temperature: 97° on July 13, 1972
Coldest temperature: −1° on January 17 and February 23, 1972
Date of last frost in spring: April 27, 1972
Date of first frost in autumn: October 10, 1972
Growing season for 1972 was 165 days *

	Avg. Max. Temp.	Avg. Min. Temp.	Avg. Temp.	Extreme Max.	Extreme Min.	Precipitation
Jan.	39	18.9	28.9	58	−1	2.35
Feb.	37.1	16.9	27	58	−1	5.82
Mar.	42.5	26.2	34.4	67	7	6.22
Apr.	53.4	32.9	43.2	76	22	3.62
May	68.7	46.8	57.8	92	38	5.28
June	76.7	56.4	66.6	91	44	7.17
July	86.1	62.4	74.3	97	51	3.87
Aug.	82.8	58.6	70.7	92	48	1.16
Sept.	76.3	53.4	64.9	91	44	7.12
Oct.	61.0	37.4	49.2	81	22	3.33
Nov.	47.2	32.2	39.7	63	15	7.80
Dec.	39.7	24.8	32.3	60	11	1.77

* Growing season — The growing season is defined as the number of days between the last day with killing frost in spring and the first day with killing frost in autumn. This time is determined by the last spring and the first fall temperature of 32 degrees F. or lower.

ALFRED J. FORDHAM

Index to Volume XXXIII

Illustrations are in **bold face.**

ARNOLDIA *is a publication of the Arnold Arboretum of Harvard University, Jamaica Plain, Massachusetts, U.S.A.*